NEW AGE

SECOND EDITION

# Perspectives in Environmental Studies

Anubha KAUSHIK - C. P. KAUSHIK

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# PERSPECTIVES IN ENVIRONMENTAL STUDIES

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SECOND EDITION

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Dedicated with Reverence to Memories of Our

***FATHER,* LATE PROF. A.K. SINHA**

*A Great Philosopher, Educationist and Humanist*

**&**

***MOTHER,* LATE SMT. ASHA RANI KAUSHIK**

*An Embodiment of Love and Dedication*

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# Preface to the Second Edition

Exponential growth of human population coupled with ways to attain high standards of living through technological advancement has resulted in widespread contamination of the environment at the global level. During the past few decades rapid industrialization, wanton exploitation of natural resources and excessive use of environmentally abhorrent materials have resulted in discernible environmental disruptions threatening the life support system. Such changes may jeopardize the very existence of life on this planet which evolved over millions of years. During these years millions of species of microorganisms, plants and animals co-evolved, the most intelligent of them being the human being, who eventually became the master of all other species and started exploiting them. Human-centric approach of development has already damaged the nature to a large extent. This has caught attention of scientists, academicians, social scientists, policy makers and the like necessitating discussions at various international and national fora. The objective of environmental protection cannot be achieved without involvement of the masses at the grass root level. To make the citizens environment conscious, the Supreme Court of India has given directive to make all curricula environment oriented. The University Grants Commission has accordingly prescribed a six months module syllabus for environmental studies for all undergraduate courses.

In this book the fundamental concept of Environmental Science and Engineering has been introduced and analysed in a simple manner strictly as per the Anna University IInd Semester syllabus.

The book has been divided into 7 units. Unit I explains the scope, importance and multidisciplinary nature of environmental studies and need for public awareness regarding environmental concerns. In Unit II, various natural resources like forest, water, mineral, food, land and energy resources are discussed along with the issues associated with their use and overexploitation. Unit III discusses natural ecosystems, their structure and function, ecosystem regulation and succession. In

unit IV, various aspects of biodiversity, its value, threats, hotspots of biodiversity, man-wildlife conflict and conservation efforts have been discussed. Unit V elaborates on various types of environmental pollution, control, prevention, solid waste management and natural disaster management. Various social issues related to growth and environmental issues of global concern along with environmental legislation are discussed in Unit VI. In the unit VII various aspects related to human population including family welfare programmes and environmental health issues are discussed. There is also focus on certain specific topics like human rights, value education, HIV/AIDS, child welfare, role of information technology etc. with special reference to environment. Case studies, mostly in the Indian context have been incorporated in these units, wherever required.

The book will be useful to the undergraduate students in science, engineering, medicine, pharmacy, humanities, commerce, management and law. Besides, this book will also be useful for those appearing in various competitive exams since environmental issues now find a focus in most of such examinations. The contents of the book will be of interest to all educationists, planners and policy makers.

Key features of the book include a simple and holistic approach with illustrations, tables and specific case studies. The basic terminologies have been defined in the text while introducing the topics and some useful terms mentioned in the text have been explained in the glossary for an easy grasp by students of all disciplines.

We are indebted to all the scientists, scholars and grass-root level workers in the field of environmental studies whose work and observations form the basis of our understanding of various scientific and social aspects of environment. We appreciate and thank our students Dr. Hardeep Rai Sharma, Er. Anil Haritash and Er. Sandeep Jain for taking pains to assist us to collect the latest data and information.

We express our deep sense of gratitude to our parents Sh. B.D. Kaushik and Mrs. Anjali Sinha for being a constant source of inspiration for us. We are grateful to our brothers and sisters for their encouragement and good wishes. We thank our nephews and nieces whose simple but penetrating queries and views about earth and environment prompted us to look at many of the aspects with a new angle. We owe special thanks to our daughter Anushmita, a Xth standard student, for her keen and inquisitive observations on various aspects of the subject and prompting us to write vividly in a simple manner to be grasped by all.

We thank the New Age International (P) Ltd. Publishers, New Delhi for their wonderful work in bringing out this edition of the book in its present form.

**Anubha Kaushik • C.P. Kaushik**
**(nee Sinha)**

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## CORE MODULE SYLLABUS FOR ENVIRONMENTAL STUDIES FOR UNDERGRADUATE COURSES OF ALL BRANCHES OF HIGHER EDUCATION

**Unit 1 : The Multidisciplinary Nature of Environmental Studies**

Definition, scope and importance (2 Lectures)

Need for public awareness.

**Unit : 2 : Natural Resources**

**Renewable and non-renewable resources :**

Natural resources and associated problems.

(*a*) **Forest resources :** Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people.

(*b*) **Water resources :** Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

(*c*) **Mineral resources :** Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

(*d*) **Food resources :** World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.

(*e*) **Energy resources :** Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources, Case studies.

(*f*) **Land resources :** Land as a resource, land degradation, man induced landslides, soil erosion and desertification.

- Role of an individual in conservation of natural resources.
- Equitable use of resources for sustainable life styles.

(8 Lectures)

**Unit 3 : Ecosystems**

- Concept of an ecosystem.
- Structure and function of an ecosystem.
- Producers, consumers and decomposers.
- Energy flow in the ecosystem.
- Ecological succession.
- Food chains, food webs and ecological pyramids.

- Introduction, types, characteristic features, structure and function of the following ecosystem :
  (*a*) Forest ecosystem
  (*b*) Grassland ecosystem
  (*c*) Desert ecosystem
  (*d*) Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries). (6 Lectures)

**Unit 4 : Bio-diversity and its Conservation**

- Introduction—Definition : genetic, species and ecosystem diversity.
- Biogeographical classification of India.
- Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values.
- Biodiversity at global, national and local levels.
- India as a maga-diversity nation.
- Hot-spots of biodiversity.
- Threats to biodiversity : habitat loss, poaching of wildlife, man-wildlife conflicts.
- Endangered and endemic species of India.
- Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity. (8 Lectures)

**Unit 5 : Environmental Pollution**

**Definition**

- Causes, effects and control measures of :
  (*a*) Air pollution
  (*b*) Water pollution
  (*c*) Soil pollution
  (*d*) Marine pollution
  (*e*) Noise pollution
  (*f*) Thermal pollution
  (*g*) Nuclear hazards.
- Solid waste management : Causes, effects and control measures of urban and industrial wastes.
- Role of an individual in prevention of pollution.
- Pollution case studies.
- Disaster management : floods, earthquake, cyclone and landslides. (8 Lectures)

**Unit 6 : Social Issues and the Environment**

- From Unsustainable to Sustainable development.
- Urban problems related to energy.
- Water conservation, rain water harvesting, watershed management.
- Resettlement and rehabilitation of people: its problems and concerns. Case studies.
- Environmental ethics: Issues and possible solutions.
- Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies.
- Wasteland reclamation.
- Consumerism and waste products.
- Environment Protection Act.
- Air (Prevention and Control of Pollution) Act.
- Water (Prevention and Control of Pollution) Act.
- Wildlife Protection Act.
- Forest Conservation Act.
- Issues involved in enforcement of environmental legislation.
- Public awareness. (7 Lectures)

**Unit 7 : Human Population and Environment**

- Population growth, variation among nations.
- Population explosion—Family Welfare Programme.
- Environment and human health.
- Human Rights.
- Value Education.
- HIV/AIDS.
- Women and Child Welfare.
- Role of Information Technology in Environment and human health.
- Case Studies. (6 Lectures)

**Unit 8 : Field Work**

- Visit to a local area to document environmental assets—river, forest grassland/hill/mountain.
- Visit to a local polluted site—Urban/Rural/Industrial/ Agricultural.
- Study of common plants, insects and birds.
- Study of simple ecosystems—pond, river, hill slopes etc. (Field work Equal to 5 lecture hours) (5 Lectures)

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(as per UGC module Syllabus)


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Unit

# 1 Environmental Studies —A Multidisciplinary Subject

'Environment' is derived from the French word *Environner* which means to encircle or surround. All the biological and non-biological things surrounding an organism are thus included in environment. Thus **environment is sum total of water, air and land, inter-relationships among themselves and also with the human beings, other living organisms and property.** The above definition given in Environment (Protection) Act, 1986 clearly indicates that environment includes all the physical and biological surroundings and their interactions. Thus, in order to study environment one needs knowledge inputs from various disciplines. Life Sciences including Botany, Zoology, Microbiology, Genetics, Biochemistry and Biotechnology help in understanding the biotic component and their interactions. The physical and chemical structure of the abiotic components and energy transfer and flow are understood with the help of basic concepts of Physics, Chemistry, Geology, Atmospheric Science, Oceanography and Geography. Mathematics, Statistics and Computer Science serve as effective tools in environmental modeling and management. Subjects like Education, Economics, Sociology and Mass communication provide the inputs for dealing with the socio-economic aspects associated with various developmental activities. A synthesis with Environmental Engineering, Civil Engineering, Hydraulics and Chemical Engineering form the basis for various technologies dealing with the control of environmental pollution, wastetreatment and development of cleaner technologies that are important for protection of the environment. Environmental laws provide the tools for effective management and protection of the environment. Environmental Studies, therefore, is a multi-disciplinary subject where different aspects are dealt with a holistic approach.

## Scope

Scope of environmental studies is broad based and it encompasses a large number of areas and aspects, broadly listed below:

- Natural Resources—their conservation and management
- Ecology and biodiversity
- Environmental pollution and control
- Social issues in relation to development and environment
- Human population and environment

These are the basic aspects of Environmental Studies which have a direct relevance to every section of the society. Environmental studies can be highly specialized also which may concentrate on more technical aspects like Environmental Science, Environmental Engineering, Environmental Management, Environmental Biotechnology etc.

Environment belongs to all and is thus important for all. Whatever be the occupation or age of a person, he or she will be affected by environment and will also affect the environment by his or her deeds. Thus, environment is one subject that is actually global in nature. For example, atmosphere has no boundaries and the pollutants produced at one place can be dispersed and transported to another place. The river water polluted by industrial or municipal discharge at one point would seriously affect the downstream aquatic life. Damage to the forests in a hilly region will have far reaching effect not only on the hills but also on the plains. This is because environment is a closely and intricately woven network of components and functions. There are some environmental problems which may be of localized importance but there are some major issues like global warming, depletion of ozone layer, dwindling forests and energy resources, loss of global biodiversity etc. that are going to affect the mankind as a whole and for that we have to think globally. For dealing with local environmental issues, e.g. the impacts of mining or hydro-electric projects, solid waste management etc. we have to think and act locally. In order to make the people aware about those aspects of environment with which they are so intimately associated, it is very important to make every one environmentally educated.

Environmental studies is very important since it deals with the most mundane issues like safe and clean drinking water, hygienic living conditions, clean and fresh air, fertile land, healthy food and development that is sustainable. There is a need for trained manpower at every level to deal with environmental issues. Environmental law, business administration and environmental engineering are emerging as new career opportunities for environmental protection and management. With the pollution control laws becoming more stringent, industries are finding it difficult to dispose off the produced wastes. In order to avoid expensive litigation, various companies are now trying

to adopt green technologies, which would reduce pollution. Investing in pollution control technologies will reduce pollution as well as cut on costs for effluent treatment. Market for pollution control technology is huge the world over. Cleaning up of the wastes produced is another potential market. It is estimated to be more than $ 100 billion per year for all American business. Germany and Japan having more stringent laws for many years have gained more experience in reducing effluents. Still there is a $ 200 billion market for cleaning up the former east Germany alone. In India also the Pollution Control Boards are seriously implementing pollution control laws and insisting on upgradation of effluents to meet the prescribed standards before they are discharged on land or into a water body. Many companies not complying with the orders have been closed or ordered to shift. This is infact essential if we want to live in a clean, healthy, aesthetically beautiful, safe and secure environment for a long time and wish to hand over a clean and safe earth to our children, grand-children and great grand children.

### Need for Public Awareness

The United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 and popularly known as **'Earth Summit'** followed by the **World Summit on Sustainable Development** at Johannesburg in 2002, just 10 years after the first summit, have highlighted the key issues of global environmental concern and have attracted the attention of the general public towards the deteriorating environment. Any government at its own level cannot achieve the goals of sustainable development until the public has a participatory role in it. Public participation is possible only when the public is aware about the ecological and environmental issues. A drive by the government to ban the littering of polythene cannot be successful until the public understands the environmental implications of the same. The public has to be educated about the fact that if we are degrading our environment we are actually harming our ownselves. This is because we are a part of the complex network of environment where every component is linked to another. It is all the more important to educate the people that sometimes the adverse impact of environment are not experienced or noticed until a threshold is crossed. So we may be caught unawares by a disaster.

There is a Chinese proverb "*It you plan for one year, plant rice, if you plan for 10 years, plant trees and if you plan for 100 years, educate people.*" If we want to manage our planet earth, we have to make all the persons environmentally educated.

In 1991, the Supreme Court of our country issued directive to make all curricula environment-oriented. This directive was, in fact, in response to a Public Interest Litigation (PIL) filed by M.C. Mehta vs. Union of India (1988) that prompted the apex court to give a mandate for creating environmental awareness among all citizens of India.

Today everybody talks of environment, but only a few have clear ideas about what needs to be done and still fewer have the actual experience or expertise in the field. Unfortunately, environmental awareness campaigns have very often been exploited for political propaganda rather than being an integral part of our educational programmes in theory and practice. "Environment" is very wrongly taken as a "fashion" by all walks of life, hardly realizing that it is our "real-life-situation" and our sustenance and security are at stake. Henry D. Thoreau rightly says "What's the use of a beautiful house if you don't have a decent planet to put it on?" Even if we begin today, the restoration is expected in the next 40-50 years.

## QUESTIONS

1. What is the need for studying environmental issues ?
2. What is the scope of environmental education ?
3. How would environmental awareness help to protect our environment ?

Unit

# 2 Natural Resources

Life on this planet earth depends upon a large number of things and services provided by the nature, which are known as Natural resources. Thus water, air, soil, minerals, coal, forests, crops and wild life are all examples of natural resources.

The natural resources are of two kinds:

- Renewable resources which are inexhaustive and can be regenerated within a given span of time e.g. forests, wildlife, wind energy, biomass energy, tidal energy, hydro power etc. Solar energy is also a renewable form of energy as it is an inexhaustible source of energy.
- Non-renewable resources which cannot be regenerated e.g. Fossil fuels like coal, petroleum, minerals etc. Once we exhaust these reserves, the same cannot be replenished.

Even our renewable resources can become non-renewable if we exploit them to such extent that their rate of consumption exceeds their rate of regeneration. For example, if a species is exploited so much that its population size declines below the threshold level then it is not able to sustain itself and gradually the species becomes endangered or extinct.

It is very important to protect and conserve our natural resources and use them in a judicious manner so that we don't exhaust them. It does not mean that we should stop using most of the natural resources. Rather, we should use the resources in such a way that we always save enough of them for our future generations. In this unit we shall discuss the major natural resources:

(*i*) Forest resources
(*ii*) Water resources
(*iii*) Mineral resources
(*iv*) Food resources
(*v*) Energy resources
(*vi*) Land resources.

## 2.1 FOREST RESOURCES

Forests are one of the most important natural resources on this earth. Covering the earth like a green blanket these forests not only produce innumerable material goods, but also provide several environmental services which are essential for life.

About 1/3rd of the world's land area is forested which includes closed as well as open forests. Former USSR accounts for about a 5th of the world's forests, Brazil for about a 7th and Canada and USA each for 6-7%. But it is a matter of concern that almost everywhere the cover of the natural forests has declined over the years. The greatest loss occurred in tropical Asia where one third of the forest resources have been destroyed.

### ■ USES OF FORESTS

**Commercial uses:** Forests provide us a large number of commercial goods which include timber, firewood, pulpwood, food items, gum, resins, non-edible oils, rubber, fibers, lac, bamboo canes, fodder, medicine, drugs and many more items, the total worth of which is estimated to be more than $ 300 billion per year.

Half of the timber cut each year is used as fuel for heating and cooking. One third of the wood harvest is used for building materials as lumber, plywood and hardwood, particle board and chipboard. One sixth of the wood harvest is converted into pulp and used for paper industry. Many forest lands are used for mining, agriculture, grazing, and recreation and for development of dams.

**Ecological uses:** While a typical tree produces commercial goods worth about $ 590 it provides environmental services worth nearly $ 196, 250.

The ecological services provided by our forests may be summed up as follows:

- **Production of oxygen:** The trees produce oxygen by photosynthesis which is so vital for life on this earth. They are rightly called as earth's lungs.
- **Reducing global warming:** The main greenhouse gas carbon dioxide ($CO_2$) is absorbed by the forests as a raw material for photosynthesis. Thus forest canopy acts as a sink for $CO_2$ thereby reducing the problem of global warming caused by greenhouse gas $CO_2$.

- **Wild life habitat:** Forests are the homes of millions of wild animals and plants. About 7 million species are found in the tropical forests alone.
- **Regulation of hydrological cycle**: Forested watersheds act like giant sponges, absorbing the rainfall, slowing down the runoff and slowly releasing the water for recharge of springs. About 50-80 %of the moisture in the air above tropical forests comes from their transpiration which helps in bringing rains.
- **Soil Conservation:** Forests bind the soil particles tightly in their roots and prevent soil erosion. They also act as wind-breaks.
- **Pollution moderators:** Forests can absorb many toxic gases and can help in keeping the air pure. They have also been reported to absorb noise and thus help in preventing air and noise pollution.

## ■ OVER EXPLOITATION OF FORESTS

Since time immemorial, humans have depended heavily on forests for food, medicine, shelter, wood and fuel. With growing civilization the demands for raw material like timber, pulp, minerals, fuel wood etc. shooted up resulting in large scale logging, mining, road-building and clearing of forests. Our forests contribute substantially to the national economy. The international timber trade alone is worth over US $ 40 billion per year. Excessive use of fuel wood and charcoal, expansion of urban, agricultural and industrial areas and overgrazing have together led to over-exploitation of our forests leading to their rapid degradation.

## ■ DEFORESTATION

The total forest area of the world in 1900 was estimated to be 7,000 million hectares which was reduced to 2890 million ha in 1975 and fell down to just 2,300 million ha by 2000. Deforestation rate is relatively less in temperate countries, but it is very alarming in tropical countries where it is as high as 40-50 percent and at the present rate it is estimated that in the next 60 years we would lose more than 90 percent of our tropical forests.

The forested area in India seems to have stabilized since 1982 with about 0.04% decline annually between 1982-90. FAO (1983) estimated that about 1.44 m ha of land was brought under afforestation during this period leading to stabilization. As per FAO estimates, the

deforestation rate per unit population in India is the lowest amongst the major tropical countries, despite the fact that we have a huge population size and very low per capita forest area (0.075 ha per capita). However, we are still far behind the target of achieving 33% forest area, as per our National Forest Policy, as we are still having only 19.27 % of our land area (63.38m ha) covered by forests based on satellite data (MoEF, 1998)

### Major Causes of Deforestation

(*i*) **Shifting cultivation:** There are an estimated 300 million people living as shifting cultivators who practice slash and burn agriculture and are supposed to clear more than 5 lakh ha of forests for shifting cultivation annually. In India, we have this practice in North-East and to some extent in Andhra Pradesh, Bihar and M.P which contribute to nearly half of the forest clearing annually.

(*ii*) **Fuel requirements:** Increasing demands for fuel wood by the growing population in India alone has shooted up to 300-500 million tons in 2001 as compared to just 65 million tons during independence, thereby increasing the pressure on forests.

(*iii*) **Raw materials for industrial use:** Wood for making boxes, furniture, railway-sleepers, plywood, match-boxes, pulp for paper industry etc. have exerted tremendous pressure on forests. Plywood is in great demand for packing tea for Tea industry of Assam while fir tree wood is exploited greatly for packing apples in J&K.

(*iv*) **Development projects:** Massive destruction of forests occur for various development projects like hydroelectric projects, big dams, road construction, mining etc.

(*v*) **Growing food needs:** In developing countries this is the main reason for deforestation. To meet the demands of rapidly growing population, agricultural lands and settlements are created permanently by clearing forests.

(*vi*) **Overgrazing:** The poor in the tropics mainly rely on wood as a source of fuel leading to loss of tree cover and the cleared lands are turned into the grazing lands. Overgrazing by the cattle leads to further degradation of these lands.

### Major Consequences of Deforestation

Deforestation has far reaching consequences, which may be outlined as follows:

(*i*) It threatens the existence of many wild life species due to destruction of their natural habitat.

(*ii*) Biodiversity is lost and along with that genetic diversity is eroded.

(*iii*) Hydrological cycle gets affected, thereby influencing rainfall.

(*iv*) Problems of soil erosion and loss of soil fertility increase.

(*v*) In hilly areas it often leads to landslides.

## CASE STUDIES

- **Desertification in hilly regions of the Himalayas**

Deforestation in Himalayas, involving clearance of natural forests and plantation of monocultures like *Pinus roxburghi, Eucalyptus camadulensis* etc. have upset the ecosystem by changing various soil (edaphic) and biological properties. Nutrient cycling has become poor, original rich germplasm is lost and the area is invaded by exotic weeds. These areas are not able to recover and are losing their fertility. The entire west Khasi hill district of Meghalaya in North-east Himalayas, Ladakh and parts of Kumaon and Garhwal are now facing the serious problem of desertification.

- **Disappearing Tea gardens in Chhota Nagpur**

This hilly region used to be a good forested area towards the turn of the century and used to receive fairly frequent afternoon showers favouring tea plantations. Following the destruction of forests, rainfall declined in Chhota Nagpur to such an extent that tea -gardens also disappeared from the region.

- **Waning Rainfall in Udhagamandalam (Ooty)**

The sub normal rainfall during 1965-84 at Ooty in Nilgiri mountains has been found to be closely associated with declining forest cover in this region in the past 20 years. The rainfall pattern was found to fluctuate with wooded land area in the hills. When the Nilgiri mountains had luxuriant forest cover annual rainfall used to be much higher.

### Major Activities in Forests

**Timber Extraction:** Logging for valuable timber, such as teak and Mahogany not only involves a few large trees per hectare but about a dozen more trees since they are strongly interlocked with each other by vines etc. Also road construction for making approach to the trees causes further damage to the forests.

**Mining:** Mining operations for extracting minerals and fossil fuels like coal often involves vast forest areas. Mining from shallow deposits is done by **surface mining** while that from deep deposits is done by **sub-surface mining**. More than 80,000 ha of land of the country is presently under the stress of mining activities. Mining and its associated activities require removal of vegetation along with underlying soil mantle and overlying rock masses. This results in defacing the topography and destruction of the landscape in the area.

Large scale deforestation has been reported in Mussorie and Dehradun valley due to indiscriminate mining of various minerals over a length of about 40 Km. The forested area has declined at an average rate of 33% and the increase in non-forest area due to mining activities has resulted in relatively unstable zones leading to landslides.

Indiscriminate mining in forests of Goa since 1961 has destroyed more than 50,000 ha of forest land. Coal mining in Jharia, Raniganj and Singrauli areas have caused extensive deforestation in Jharkhand. Mining of magnesite and soap- stones have destroyed 14 ha of forest in the hill slopes at Khirakot, Kosi valley, Almora. Mining of radioactive minerals in Kerala, Tamilnadu and Karnataka are posing similar threats of deforestation. The rich forests of Western Ghats are also facing the same threat due to mining projects for excavation of copper, chromite, bauxite and magnetite.

## ■ DAMS AND THEIR EFFECTS ON FORESTS AND PEOPLE

Big dams and river valley projects have multi-purpose uses and have been referred to as *"Temples of modern India".* However, these dams are also responsible for the destruction of vast areas of forests. India has more than 1550 large dams, the maximum being in the state of Maharashtra (more then 600), followed by Gujarat (more then 250) and Madhya Pradesh (130). The highest one is *Tehri dam*, on river Bhagirathi in Uttaranchal and the largest in terms of capacity is Bhakra dam on river Satluj in H.P. Big dams have been in sharp focus of various environmental groups all over the world which is mainly because of several ecological problems including deforestation and socio-economic problems related to tribal or native people associated with them. The

*Silent Valley* hydroelectric project was one of the first such projects situated in the tropical rain forest area of Western Ghats which attracted much concern of the people. *The crusade against the ecological damage and deforestation caused due to Tehri dam was led by Sh. Sunder lal Bahuguna, the leader of Chipko movement. The cause of Sardar Sarovar Dam related issues has been taken up by the environmental activists Medha Patekar, joined by Arundhati Ray and Baba Amte.*

For building big dams, large scale devastation of forests takes place which breaks the natural ecological balance of the region. Floods, droughts and landslides become more prevalent in such areas. Forests are the repositories of invaluable gifts of nature in the form of biodiversity and by destroying them ( particularly, the tropical rain forests) we are going to lose these species even before knowing them. These species could be having marvelous economic or medicinal value and deforestation results in loss of this storehouse of species which have evolved over millions of years in a single stroke.

**Sardar Sarovar Dam (Uprooted Forests And Tribals): A case study**

The dam is situated on river Narmada and is spread over three states of Gujarat, Maharashtra and Madhya Pradesh. Although the project is aimed at providing irrigation water, drinking water and electricity to the three states, the environmental impacts of the project have raised challenging questions.

A total of 1,44,731 ha of land will be submerged by the dam, out of which 56,547 ha is forest land. A total of 573 villages are to be submerged by the Narmada Dam.

Submergence of about 40,000 ha of forest under Narmada Sagar, 13,800 ha under Sardar Sarovar and 2,500 ha under Omkareshwar would further create pressure on remaining forest areas in adjoining areas. Submergence area is very rich in wildlife e.g. tigers, panthers, bears, wolves, pangolins, hyenas, jackals, flying squirrels, antelopes, black bucks, chinkara, marsh crocodiles, turtles etc. Many of these species are listed in schedule I & II of Wildlife Protection Act, 1972. Thus massive loss of these wildlife species is apprehended due to the devastation of the forest under the project.

As per the estimates of the Institute of Urban Affairs, New Delhi, the Narmada valley project will lead to eventual displacement of more than one million people, which is probably the largest

(*Contd.*)

rehabilitation issue ever encountered as per the World Bank. Uprooting of the tribals and their forced shifting in far-flung areas may not be easily adjusted to. Besides serious economic deprivation, the displacement will affect the tribal peoples' culture, their beliefs, myths and rituals, festivals, songs and dances, all closely associated with the hills, forest and streams. Most of these tribals belong to poor, unprivileged schedule castes and tribes who are being uprooted from a place where they have lived for generations. The displaced persons have to undergo hardship and distress for the sake of development and prosperity of a larger section of the society. It is therefore the duty of the project proponents and government to pay maximum attention for proper rehabilitation of the displaced tribals.

## 2.2 WATER RESOURCES

Water is an indispensable natural resource on this earth on which all life depends. About 97% of the earth's surface is covered by water and most of the animals and plants have 60-65% water in their body.

Water is characterized by certain unique features which make it a marvellous resource:

(*i*) It exists as a liquid over a wide range of temperature i.e. from 0° to100°C.

(*ii*) It has the highest specific heat, due to which it warms up and cools down very slowly without causing shocks of temperature jerks to the aquatic life.

(*iii*) It has a high latent heat of vaporization Hence, it takes a huge amount of energy for getting vaporized. That's why it produces a cooling effect as it evaporates.

(*iv*) It is an excellent solvent for several nutrients. Thus, it can serve as a very good carrier of nutrients, including oxygen, which are essential for life. But, it can also easily dissolve various pollutants and become a carrier of pathogenic microorganisms.

(*v*) Due to high surface tension and cohesion it can easily rise through great heights through the trunk even in the tallest of the trees like *Sequoia*.

(*vi*) It has an anamolous expansion behaviour i.e. as it freezes, it expands instead of contracting and thus becomes lighter. It is because of this property that even in extreme cold, the lakes freeze only on the surface. Being lighter the ice keeps floating, whereas the bottom waters remain at a higher temperature and therefore, can sustain aquatic organisms even in extreme cold.

The water we use keeps on cycling endlessly through the environment, which we call as **Hydrological Cycle**. We have enormous resources of water on the earth amounting to about 1404 million $Km^3$. The water from various moist surfaces evaporates and falls again on the earth in the form of rain or snow and passes through living organisms and ultimately returns to the oceans. Every year about 1.4 inch thick layer of water evaporates from the oceans, more than 90% of which returns to the oceans through the hydrological cycle. Solar energy drives the water cycle by evaporating it from various water bodies, which

subsequently return through rainfall or snow. Plants too play a very important role by absorbing the groundwater from the soil and releasing it into the atmosphere by the process of transpiration.

Global distribution of water resources is quite uneven depending upon several geographic factors. Tropical rain forest areas receive maximum rainfall while the major world deserts occur in zones of dry, descending air (20-40° N and S) and receive very little rainfall.

## ■ WATER USE AND OVER-EXPLOITATION

Due to its unique properties water is of multiple uses for all living organisms. Water is absolutely essential for life. Most of the life processes take place in water contained in the body. Uptake of nutrients, their distribution in the body, regulation of temperature, and removal of wastes are all mediated through water.

Human beings depend on water for almost every developmental activity. Water is used for drinking, irrigation, transportation, washing and waste disposal for industries and used as a coolant for thermal power plants. Water shapes the earth's surface and regulates our climate.

**Water use** by humans is of two types: **water withdrawal:** taking water from groundwater or surface water resource and **water consumption:** the water which is taken up but not returned for reuse. Globally, only about 60 percent of the water withdrawn is consumed due to loss through evaporation.

With increasing human population and rapid development, the world water withdrawal demands have increased many folds and a large proportion of the water withdrawn is polluted due to anthropogenic activities. On a global average 70 percent of the water withdrawn is used for agriculture. In India, we use 93% of water in agricultural sector while in a country like Kuwait, which is water-poor, only 4% is used for watering the crops. About 25% of water on global average is used in industry, which again varies from a high of 70% in European countries to as low as 5% in less developed countries. Per capita use of water shows wide variations. In USA, an average family of 4 consumes more than 1000 $M^3$ of water per year, which is many times more than that in most developing countries.

### Water: A Precious Natural Resource

Although water is very abundant on this earth, yet it is very precious. Out of the total water reserves of the world, about 97% is salty water

(marine) and only 3% is fresh water. Even this small fraction of fresh water is not available to us as most of it is locked up in polar ice caps and just 0.003% is readily available to us in the form of groundwater and surface water.

Overuse of groundwater for drinking, irrigation and domestic purposes has resulted in rapid depletion of groundwater in various regions leading to lowering of water table and drying of wells. Pollution of many of the groundwater aquifers has made many of these wells unfit for consumption.

Rivers and streams have long been used for discharging the wastes. Most of the civilizations have grown and flourished on the banks of rivers, but unfortunately, growth in turn, has been responsible for pollution of the rivers.

As per the United Nations estimates (2002), at least 101 billion people do not even have access to safe drinking water and 2.4 billion do not have adequate sanitation facilities. Increasing population and expanding development would further increase the demands for wastes. It is estimated that by 2024, two-thirds of the world population would be suffering from acute water shortage.

## Groundwater

About 9.86% of the total fresh water resources is in the form of groundwater and it is about 35-50 times that of surface water supplies. Till some time back groundwater was considered to be very pure. However, of late, even groundwater aquifers have been found to be contaminated by leachates from sanitary landfills etc.

A layer of sediment or rock that is highly permeable and contains water is called an **aquifer**. Layers of sand and gravel are good aquifers while clay and crystalline rocks (like granite) are not since they have low permeability. Aquifers may be of two types:

**Unconfined aquifers** which are overlaid by permeable earth materials and they are recharged by water seeping down from above in the form of rainfall and snow melt.

**Confined aquifers** which are sandwitched between two impermeable layers of rock or sediments and are recharged only in those areas where the aquifer intersects the land surface. Sometimes the recharged area is hundreds of kilometers away from the location of the well. Fig 2.2.1 shows the groundwater system. Groundwater is not static, it moves, though at a very slow rate of about a meter or so in a year.

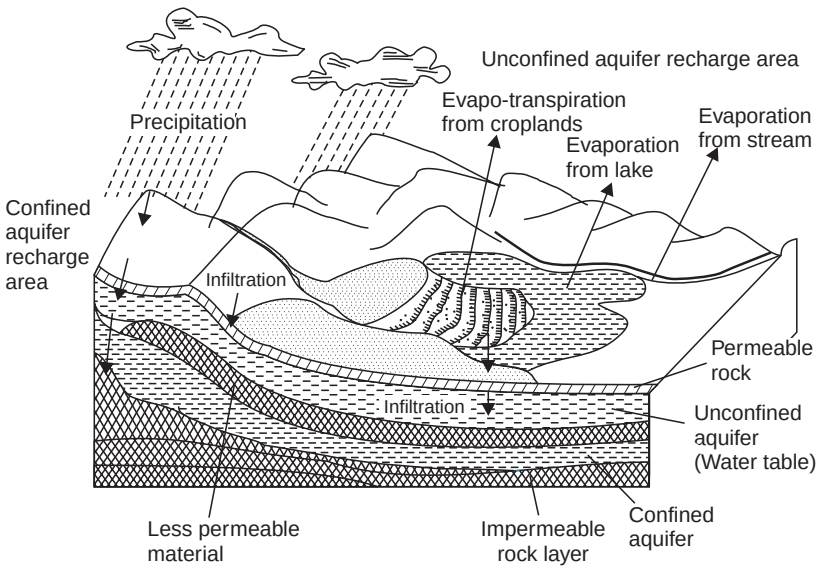



Fig. 2.2.1. The groundwater system. An unconfined aquifer (water table) is formed when water collects over a rock or compact clay. A confined aquifer is formed sandwitched between two layers having very low permeability.

## Effects of Groundwater Usage

(*i*) **Subsidence:** When groundwater withdrawal is more than its recharge rate, the sediments in the aquifer get compacted, a phenomenon known as *ground subsidence*. Huge economic losses may occur due to this phenomenon because it results in the sinking of overlying land surface. The common problems associated with it include structural damage in buildings, fracture in pipes, reversing the flow of sewers and canals and tidal flooding.

(*ii*) **Lowering of water table:** Mining of groundwater is done extensively in arid and semi-arid regions for irrigating crop fields. However, it is not advisable to do excessive mining as it would cause a sharp decline in future agricultural production, due to lowering of water table.

(*iii*) **Water logging:** When excessive irrigation is done with brackish water it raises the water table gradually leading to water-logging and salinity problems.

### Surface Water

The water coming through precipitation (rainfall, snow) when does not percolate down into the ground or does not return to the atmosphere as evaporation or transpiration loss, assumes the form of streams, lakes, ponds, wetlands or artificial reservoirs known as surface water. The surface water is largely used for irrigation, industrial use, public water supply, navigation etc. A country's economy is largely dependent upon its rivers.

**Water rich vs. Water poor countries**

The top ten water rich countries are Iceland, Surinam, Guyana, Papua New Guinea, Gabon, Solomon Islands, Canada, Norway, Panama, and Brazil lying in the far north and have low evaporation losses.

The water poor countries include Kuwait, Egypt, United Arab Emirates, Malta, Jordon, Saudi Arabia, Singapore, Maldovia, Israel and Oman, lying in the desert belt at about 15° to 25° Latitude and some of them like Malta and Singapore are densely populated areas resulting in low per capita water.

## ■ FLOODS

In some countries like India and Bangladesh rainfall does not occur throughout the year, rather, 90% of it is concentrated into a few months (June-September). Heavy rainfall often causes floods in the low-lying coastal areas. Prolonged downpour can also cause the over-flowing of lakes and rivers resulting into floods.

Deforestation, overgrazing, mining, rapid industrialization, global warming etc. have also contributed largely to a sharp rise in the incidence of floods, which otherwise is a natural disaster.

Floods have been regular features of some parts of India and Bangladesh causing huge economic loss as well as loss of life. People of Bangladesh are accustomed to moderate flooding during monsoon and they utilize the flood water for raising paddy. But, severe floods like that in 1970, 1988 and 1991 resulting from excessive Himalayan runoff and storms, had very disastrous consequences causing massive deaths and damages. In 1970, about one million people were drowned while 1,40,000 people died in 1991. Networking of rivers is being proposed at national level to deal with the problems of floods.

## ■ DROUGHTS

There are about 80 countries in the world, lying in the arid and semi-arid regions that experience frequent spells of droughts, very often extending up to year long duration. **When annual rainfall is below normal and less than evaporation, drought conditions are created.** Ironically, these drought- hit areas are often having a high population growth which leads to poor land use and makes the situation worse.

**Anthropogenic causes:** Drought is a meteorological phenomenon, but due to several anthropogenic causes like over grazing, deforestation, mining etc. there is spreading of the deserts tending to convert more areas to drought affected areas. In the last twenty years, India has experienced more and more desertification, thereby increasing the vulnerability of larger parts of the country to droughts.

Erroneous and intensive cropping pattern and increased exploitation of scarce water resources through well or canal irrigation to get high productivity has converted drought - prone areas into desertified ones. In Maharashtra there has been no recovery from drought for the last 30 years due to over-exploitation of water by sugarcane crop which has high water demands.

**Remedial measures:** Indigenous knowledge in control of drought and desertification can be very useful for dealing with the problem. Carefully selected mixed cropping help optimize production and minimize the risks of crop failures. Social Forestry and Wasteland development can prove quite effective to fight the problem, but it should be based on proper understanding of ecological requirements and natural process, otherwise it may even boomrang. The Kolar district of Karnataka is one of the leaders in Social Forestry with World Bank Aid, but all its 11 talukas suffer from drought. It is because the tree used for plantation here was *Eucalyptus* which is now known to lower the water table because of its very high transpiration rate.

## ■ CONFLICTS OVER WATER

Indispensability of water and its unequal distribution has often led to inter-state or international disputes. Issues related to sharing of river water have been largely affecting our farmers and also shaking our governments. Some major water conflicts are discussed here.

- **Water conflict in the Middle East:** Three river basins, namely the Jordan, the Tigris-Euphrates and the Nile are the shared water resources for Middle East countries. Ethiopia controls the head waters of 80% of Nile's flow and plans to increase it.

Sudan too is trying to divert more water. This would badly affect Egypt, which is a desert, except for a thin strip of irrigated cropland along the river Nile and its delta.

The population of Egypt is likely to double in the next 20 years, thereby increasing its water crisis. Likewise there is a fierce battle for water among Jordan, Syria and Israel for the Jordan River water share.

Turkey has abundant water and plans to build 22 dams on Tigris-Euphrates for Hydroelectric power generation. But, it would drastically reduce the flow of water to Syria and Iraq, lying downstream. Turkey dreams to become the region's water Super power. It plans to transport and sell water to starved Saudi Arabia, Kuwait, Syria, Israel and Jordan. Probably, the next war in the Middle East would be fought over water and not oil.

- **The Indus Water Treaty:** The Indus, one of the mightiest rivers is dying a slow death due to dams and barrages that have been built higher up on the river. The Sukkur barrage (1932), Ghulam Mohamad Barrage at Kotri (1958) and Tarbela and Chasma Dams on Jhelum, a tributary of Indus have resulted in severe shrinking of the Indus delta. In 1960, the Indus water treaty was established vide which Indus, the Jhelum and the Chenab were allocated to Pakistan and the Satluj, the Ravi and the Beas were allocated to India. Being the riparian state, India has pre-emptive right to construct barrages across all these rivers in Indian territory. However, the treaty requires that the three rivers allocated to Pakistan may be used for *non-consumptive* purposes by India i.e. without changing its flow and quality. With improving political relations between the two countries it is desirable to work out techno-economic details and go for an integrated development of the river basin in a sustainable manner.
- **The Cauvery water dispute:** Out of India's 18 major rivers, 17 are shared between different states. In all these cases, there are intense conflicts over these resources which hardly seem to resolve. The Cauvery river water is a bone of contention between Tamilnadu and Karnataka and the fighting is almost hundred years old. Tamilnadu, occupying the downstream region of the river wants water-use regulated in the upstream. Whereas, the upstream state Karnataka refuses to do so and claims its primacy over the river as upstream user. The river

water is almost fully utilized and both the states have increasing demands for agriculture and industry. The consumption is more in Tamilnadu than Karnataka where the catchment area is more rocky. On June 2,1990, the Cauvery Water Dispute Tribunal was set up which through an interim award directed Karnataka to ensure that 205 TMCF of water was made available in Tamil Nadu's Mettur dam every year, till a settlement was reached. In 1991-92 due to good monsoon, there was no dispute due to good stock of water in Mettur, but in 1995, the situation turned into a crisis due to delayed rains and an expert Committee was set up to look into the matter which found that there was a complex cropping pattern in Cauvery basin. *Sambra* paddy in winter, *Kurvai* paddy in summer and some cash crops demanded intensive water, thus aggravating the water crisis. Proper selection of crop varieties, optimum use of water, better rationing, rational sharing patterns, and pricing of water are suggested as some measures to solve the problem.

- **The Satluj-Yamuna link (SYL) canal dispute:** The issue of sharing the Ravi-Beas waters and SYL issue between Punjab and Haryana is being discussed time and again and the case is in the Supreme Court. The Eradi Tribunal (1985) based the allocation of water on the basis of the time-inflow data of 20 years (1960-80), according to which 17.17 MAF (million acre feet) water was available. However, now it is argued by Punjab that in the last 17 years there has been consistent decline reducing the quantity to 14.34 MAF. The Supreme Court on January 15, 2002 directed Punjab to complete and commission the SYL within a year, failing which the Center was told to complete it. However, two years have passed, but neither the SYL has been completed nor the conflict over sharing of Ravi-Beas water is resolved.

  The conflict is that Punjab being the riparian state for Beas, Ravi and Satluj stakes its claim, Haryana has faced acute shortage of water after it became a state in 1966 and has been trying to help it out by signing an MOU (Memorandum of understanding) with UP, Rajasthan and Delhi for allocation of Yamuna waters. The Yamuna basin covers the state of Haryana while the Indus basin covers Punjab.

  The conflict revolving around sharing of river water needs to be tackled with greater understanding and objectivity.

### Traditional Water Management System

In India, even today, there are several villages where water management is done not by the Irrigation Department, but by local managers. In south India, a ***neerkatti*** manages the traditional tanks very efficiently based on his/her knowledge of the terrain, drainage and irrigation needs. They usually give preference to the tail end fields and decide per capita allocation of water based on the stock of available water in the tank and crop needs. In Maharashtra, the water mangers are called ***havaldars*** or ***jaghyas*** who manage and resolve conflicts by overseeing the water channels from main canal to the distributory canals. In Ladakh, the water manager is known as ***churpun*** who has got complete charge with full powers over allocation of available water. The major source of water is melt water from glaciers and snow supplementary by water from springs and marshes. The water is distributed to different fields through an intricate network of earthen channels.

In traditional water management, innovative arrangements ensure equitable distribution of water, which are democratically implemented. The 'gram-sabhas' approve these plans publicly. While water disputes between states and nations often assume battle like situations, our traditional water managers in villages prove to be quite effective.

## ■ BIG DAMS- BENEFITS AND PROBLEMS

### Benefits

River valley projects with big dams have usually been considered to play a key role in the development process due to their multiple uses. India has the distinction of having the largest number of river-valley projects. These dams are often regarded as a symbol of national development. The tribals living in the area pin big hopes on these projects as they aim at providing employment and raising the standard and quality of life. The dams have tremendous potential for economic upliftment and growth. They can help in checking floods and famines, generate electricity and reduce water and power shortage, provide irrigation water to lower areas, provide drinking water in remote areas and promote navigation, fishery etc.

### Environmental Problems

The environmental impacts of big-dams are also too many due to which very often the big dams become a subject of controversy. The impacts can be at the upstream as well as downstream levels.

(A) The upstream problems include the following:

(*i*) Displacement of tribal people

(*ii*) Loss of forests, flora and fauna

(*iii*) Changes in fisheries and the spawning grounds

(*iv*) Siltation and sedimentation of reservoirs

(*v*) Loss of non-forest land

(*vi*) Stagnation and waterlogging near reservoir

(*vii*) Breeding of vectors and spread of vector-borne diseases

(*viii*) Reservoir induced seismicity (RIS) causing earthquakes

(*ix*) Growth of aquatic weeds.

(*x*) Microclimatic changes.

(B) The downstream impacts include the following:

(*i*) Water logging and salinity due to over irrigation

(*ii*) Micro-climatic changes

(*iii*) Reduced water flow and silt deposition in river

(*iv*) Flash floods

(*v*) Salt water intrusion at river mouth

(*vi*) Loss of land fertility along the river since the sediments carrying nutrients get deposited in the reservoir

(*vii*) Outbreak of vector-borne diseases like malaria

Thus, although dams are built to serve the society with multiple uses, but it has several serious side-effects. That is why now there is a shift towards construction of small dams or mini-hydel projects.

## 2.3 MINERAL RESOURCES

Minerals are naturally occurring, inorganic, crystalline solids having a definite chemical composition and characteristic physical properties. There are thousands of minerals occurring in different parts of the world. However, most of the rocks, we see everyday are just composed of a few common minerals like quartz, feldspar, biotite, dolomite, calcite, laterite etc. These minerals, in turn, are composed of some elements like silicon, oxygen, iron, magnesium, calcium, aluminium etc.

### ■ USES AND EXPLOITATION

Minerals find use in a large number of ways in everyday use in domestic, agricultural, industrial and commercial sectors and thus form a very important part of any nation's economy. The main uses of minerals are as follows:

(*i*) Development of industrial plants and machinery.
(*ii*) Generation of energy e.g. coal, lignite, uranium.
(*iii*) Construction, housing, settlements.
(*iv*) Defence equipments-weapons, armaments.
(*v*) Transportation means.
(*vi*) Communication- telephone wires, cables, electronic devices.
(*vii*) Medicinal system- particularly in Ayurvedic System.
(*viii*) Formation of alloys for various purposes (e.g. phosphorite).
(*ix*) Agriculture–as fertilizers, seed dressings and fungicides (e.g. zineb containing zinc, Maneb-containing manganese etc.).
(*x*) Jewellery–e.g. Gold, silver, platinum, diamond.

Based on their properties, minerals are basically of two types:

(*i*) Non metallic minerals e.g. graphite, diamond, quartz, feldspar.
(*ii*) Metallic minerals e.g. Bauxite, laterite, haematite etc.

Use of metals by human beings has been so extensive since the very beginning of human civilization that two of the major epochs of human history are named after them as Bronze Age and Iron Age. The reserves of metals and the technical know-how to extract them have been the key elements in determining the economy and political power of nations. Out of the various metals, the one used in maximum quantity is Iron and steel (740 million metric tons annually) followed by manganese, copper, chromium, aluminium and Nickel.

Distribution and uses of some of the major metallic and non-metallic minerals are given in Tables 2.3.1 and 2.3.2.

**Table 2.3.1. Major reserves and important uses of some of the major metals**

| Metal | Major World Reserves | Major Uses |
|---|---|---|
| Aluminium | Australia, Guinea, Jamaica | Packaging food items, transportation, utensils, electronics |
| Chromium | CIS, South Africa | For making high strength steel alloys, In textile/tanning industries |
| Copper | U.S.A., Canada, CIS, Chile, Zambia | Electric and electronic goods, building, construction, vessels |
| Iron | CIS, South America, Canada, U.S.A. | Heavy machinery, steel production transportation means |
| Lead | North America, U.S.A., CIS | Leaded gasoline, Car batteries, paints, ammunition |
| Manganese | South Africa, CIS, Brazil, Gabon | For making high strength, heat-resistant steel alloys |
| Platinum group | South Africa, CIS | Use in automobiles, catalytic converters, electronics, medical uses. |
| Gold | South Africa, CIS, Canada | Ornaments, medical use, electronic use, use in aerospace |
| Silver | Canada, South Africa, Mexico | Photography, electronics jewellery |
| Nickel | CIS, Canada, New Caledonia | Chemical industry, steel alloys |

**Table 2.3.2. Major uses of some non-metallic minerals**

| Non-metal Mineral | Major Uses |
|---|---|
| Silicate minerals | Sand and gravel for construction, bricks, paving etc. |
| Limestone | Used for concrete, building stone, used in agriculture for neutralizing acid soils, used in cement industry |
| Gypsum | Used in plaster wall-board, in agriculture |
| Potash, phosphorite | Used as fertilizers |
| Sulphur pyrites | Used in medicine, car battery, industry. |

It is evident from the Tables that the CIS countries (The Commonwealth of Independent States *i.e.* 12 repubics of former USSR), the United States of America, Canada, South Africa and Australia are having the major world reserves of most of the metallic minerals. Due to huge mineral and energy resources, the USA became the richest and the most powerful nation in the world in even less than 200 years. Japan too needs a mention here, as there are virtually no metal reserves, coal, oil and timber resources in Japan and it is totally dependent on other countries for its resources. But, it has developed energy efficient technologies to upgrade these resources to high quality finished products to sustain its economy.

Minerals are sometimes classified as **Critical** and **Strategic**.

**Critical minerals** are essential for the economy of a nation e.g. iron, aluminium, copper, gold etc.

**Strategic minerals** are those required for the defence of a country e.g. Manganese, cobalt, platinum, chromium etc.

### Some Major Minerals of India

(*a*) **Energy generating minerals**

***Coal and lignite:*** West Bengal, Jharkhand, Orissa, M.P., A.P.

***Uranium*** (Pitchblende or Uranite ore): Jharkhand, Andhra Pradesh (Nellore, Nalgonda), Meghalaya, Rajasthan (Ajmer).

(*b*) **Other commercially used minerals**

***Aluminium*** *(Bauxite ore):* Jharkhand, West Bengal, Maharashtra, M.P., Tamilnadu.

***Iron*** *(haematite and magnetite ore):* Jharkhand, Orissa, M.P., A.P., Tamilnadu, Karnataka, Maharashtra and Goa.

***Copper*** *(Copper Pyrites):* Rajasthan (Khetri), Bihar, Jharkhand, Karnataka, M.P., West Bengal, Andhra Pradesh and Uttaranchal.

## ■ ENVIRONMENTAL IMPACTS OF MINERAL EXTRACTION AND USE

The issue related to the limits of the mineral resources in our earth's crust or in the ocean is not so significant. More important environmental concern arises from the impacts of extraction and processing of these minerals during mining, smelting etc.

**Indian Scenario:** India is the producer of 84 minerals the annual value of which is about Rs. 50,000 crore. At least six major mines need a mention here which are known for causing severe problems:

(*i*) **Jaduguda Uranium Mine, Jharkhand**—exposing local people to radioactive hazards.

(*ii*) **Jharia coal mines, Jharkhand**—underground fire leading to land subsidence and forced displacement of people.

(*iii*) **Sukinda chromite mines, Orissa**—seeping of hexavalent chromium into river posing serious health hazard, $Cr^{6+}$ being highly toxic and carcinogenic.

(*iv*) **Kudremukh iron ore mine, Karnataka**—causing river pollution and threat to biodiversity.

(*v*) **East coast Bauxite mine, Orissa**—Land encroachment and issue of rehabilitation unsettled.

(*vi*) **North-Eastern Coal Fields, Assam**—Very high sulphur contamination of groundwater.

**Impacts of mining:** Mining is done to extract minerals (or fossil fuels) from deep deposits in soil by using **sub-surface mining** or from shallow deposits by **surface mining**. The former method is more destructive, dangerous and expensive including risks of occupational hazards and accidents.

Surface mining can make use of any of the following three types:

(*a*) *Open-pit mining* in which machines dig holes and remove the ores (e.g. copper, iron, gravel, limestone, sandstone, marble, granite).

(*b*) *Dredging* in which chained buckets and draglines are used which scrap up the minerals from under-water mineral deposits.

(*c*) *Strip mining* in which the ore is stripped off by using bulldozers, power shovels and stripping wheels (e.g. phosphate rocks).

The environmental damage caused by mining activities are as follows:

(*i*) **Devegetation and defacing of landscape:** The topsoil as well as the vegetation are removed from the mining area to get access to the deposit. While large scale deforestation or devegetation leads to several ecological losses as already discussed in the previous section, the landscape also gets badly affected. The huge quantities of debris and tailings alongwith big scars and disruptions spoil the aesthetic value of the region and make it prone to soil erosion.

(*ii*) **Subsidence of land:** This is mainly associated with underground mining. Subsidence of mining areas often results in tilting of buildings, cracks in houses, buckling of roads,

bending of rail tracks and leaking of gas from cracked pipelines leading to serious disasters.

(*iii*) **Groundwater contamination:** Mining disturbs the natural hydrological processes and also pollutes the groundwater. Sulphur, usually present as an impurity in many ores is known to get converted into sulphuric acid through microbial action, thereby making the water acidic. Some heavy metals also get leached into the groundwater and contaminate it posing health hazards.

(*iv*) **Surface water pollution:** The acid mine drainage often contaminates the nearby streams and lakes. The acidic water is detrimental to many forms of aquatic life. Sometimes radioactive substances like uranium also contaminate the water bodies through mine wastes and kill aquatic animals. Heavy metal pollution of water bodies near the mining areas is a common feature creating health hazards.

(*v*) **Air pollution:** In order to separate and purify the metal from other impurities in the ore, smelting is done which emits enormous quantities of air pollutants damaging the vegetation nearby and has serious environmental health impacts. The suspended particulate matter (SPM), SOx, soot, arsenic particles, cadmium, lead etc. shoot up in the atmosphere near the smelters and the public suffers from several health problems.

(*vi*) **Occupational Health Hazards:** Most of the miners suffer from various respiratory and skin diseases due to constant exposure to the suspended particulate matter and toxic substances. Miners working in different types of mines suffer from asbestosis, silicosis, black lung disease etc.

**Remedial measures:** Safety of mine workers is usually not a priority subject of industry. Statistical data show that, on an average, there are 30 non-fatal but disabling accidents per ton of mineral produced and one death per 2.5 tons of mineral produced.

In order to minimize the adverse impacts of mining it is desirable to adopt eco-friendly mining technology. The low-grade ores can be better utilized by using **microbial-leaching technique.** The bacterium *Thiobacillus ferroxidans* has been successfully and economically used for extracting gold embedded in iron sulphide ore. The ores are inoculated with the desired strains of bacteria, which remove the impurities (like sulphur) and leave the pure mineral. This biological method is helpful from economic as well as environmental point of view.

Restoration of mined areas by re-vegetating them with appropriate plant species, stabilization of the mined lands, gradual restoration of flora, prevention of toxic drainage discharge and conforming to the standards of air emissions are essential for minimizing environmental impacts of mining.

## CASE STUDIES

- **Mining and quarrying in Udaipur**

About 200 open cast mining and quarrying centers in Udaipur, about half of which are illegal are involved in stone mining including soapstone, building stone, rock phosphate and dolomite. The mines spread over 15,000 hectares in Udaipur have caused many adverse impacts on environment. About 150 tonnes of explosives are used per month in blasting. The overburden, washoff, discharge of mine water etc. pollute the water. The Maton mines have badly polluted the Ahar river. The hills around the mines are devoid of any vegetation except a few scattered patches and the hills are suffering from acute soil erosion. The waste water flows towards a big tank of "Bag Dara". Due to scarcity of water people are compelled to use this effluent for irrigation purpose.

The blasting activity has adversely affected the fauna and the animals like tiger, lion, deer and even hare, fox, wild cats and birds have disappeared from the mining area.

- **Mining in Sariska Tiger Reserve in Aravallis**

The Aravalli range is spread over about 692 km in the North-west India covering Gujarat, Rajasthan, Haryana and Delhi. The hill region is very rich in biodiversity as well as mineral resources. The Sariska tiger reserve has gentle slopy hills, vertical rocky valleys, flat plains as well as deep gorges. The reserve is very rich in wild life and has enormous mineral reserves like quartzite, Schists, marble and granite in abundance.

Mining operations within and around the Sariska Tiger reserve has left many areas permanently infertile and barren. The precious wild life is under serious threat. We must preserve the Aravalli series as a National Heritage and the Supreme Court on December 31st, 1991 has given a judgement in response to a Public Interest Litigation of Tarun Bharat Sangh, an NGO wherein both Centre and State Government of Rajasthan have been directed to ensure that all mining activity within the park be stopped. More than 400 mines were shut immediately. But, still some illegal mining is in progress.

• **Uranium Mining in Nalgonda, A.P.—The public hearing**

The present reserves of Uranium in Jaduguda mines, Jharkhand can supply the yellow cake only till 2004. There is a pressing need for mining more uranium to meet the demands of India's nuclear programme. The Uranium Corporation of India (UCIL) proposes to mine uranium from the deposits in Lambapur and Peddagattu villages of Nalgonda district in Andhra Pradesh and a processing unit at about 18 kms at Mallapur. The plan is to extract the ore of 11.02 million tons in 20 years. The IUCL is trying its best to allure the villagers through employment opportunities. But, experts charge the company for keeping silence on the possible contamination of water bodies in the area. The proposed mines are just 1 km from human habitation and hardly 10 km from Nagarjun Sagar Dam and barely 4 km from the Akkampalli reservoir which is Hyderabad's new source of drinking water.

It is estimated that 20 years of mining would generate about 7.5 million metric tones of radioactive waste of which 99.9% will be left behind. The villagers are very likely to be affected by the radioactive wastes. Though IUCL claims that there won't be any such accidents, but no one can deny that it is a highly hazardous industry and safety measures cannot be overlooked. The pathetic condition of Jaduguda Uranium mines in Jharkhand where there is a black history of massive deaths and devastation have outraged the public, who don't want it to be repeated for Nalgonda.

The proposed mines would cover about 445 ha of Yellapurum Reserve Forest and the Rajiv Gandhi Tiger Sanctuary. The public hearing held just recently in February, 2004 witnessed strong protests from NGOs and many villagers. The fate of the proposed mining is yet to be decided.

## 2.4 FOOD RESOURCES

We have thousands of edible plants and animals over the world out of which only about three dozen types constitute the major food of humans. The main food resources include wheat, rice, maize, potato, barley, oats, cassava, sweet potato, sugarcane, pulses, sorghum, millet, about twenty or so common fruits and vegetables, milk, meat, fish and seafood. Amongst these rice, wheat and maize are the major grains, about 1500 million metric tons of which are grown each year, which is about half of all the agricultural crops. About 4 billion people in the developing countries have wheat and rice as their staple food.

Meat and milk are mainly consumed by more developed nations of North America, Europe and Japan who consume about 80% of the total. Fish and sea-food contribute about 70 million metric tons of high quality protein to the world's diet. But there are indications that we have already surpassed sustainable harvests of fish from most of the world's oceans.

The Food and Agriculture Organization (FAO) of United Nations estimated that on an average the minimum caloric intake on a global scale is 2,500 calories/day. People receiving less than 90% of these minimum dietary calories are called **undernourished** and if it is less than 80% they are said to be **seriously undernourished**. Besides the minimum caloric intake we also need proteins, minerals etc. Deficiency or lack of nutrition often leads to **malnutrition** resulting in several diseases as shown in Table 2.4.1.

**Table 2.4.1. Impacts of malnutrition**

| Deficiency | Health Effect | No. of Cases | Deaths per year (in millions) |
|---|---|---|---|
| Proteins and Calories | Stunted growth, Kwashiorkor, Marasmus | 750<br>1 million | 15-20 |
| Iron | Anemia | 350 million | 0.75-1 |
| Iodine | Goitre, Cretinism | 150 million,<br>6 million | |
| Vitamin A | Blindness | 6 million | |

## ■ WORLD FOOD PROBLEMS

During the last 50 years world grain production has increased almost three times, thereby increasing per capita production by about 50%. But, at the same time population growth increased at such a rate in LDCs (Less developed countries) that it outstripped food production. Every year 40 million people (fifty percent of which are young children between 1 to 5 years) die of undernourishment and malnutrition. This means that ***every year our food problem is killing as many people as were killed by the atomic bomb dropped on Hiroshima during World War II.*** These startling statistical figures more than emphasize the need to increase our food production, equitably distribute it and also to control population growth.

**Indian Scenario:** Although India is the third largest producer of staple crops, an estimated 300 million Indians are still undernourished. India has only half as much 1and as USA, but it has nearly three times population to feed. Our food problems are directly related to population.

The **World Food Summit, 1996** has set the target to reduce the number of undernourished to just half by 2015, which still means 410 million undernourished people on the earth.

## ■ IMPACTS OF OVERGRAZING AND AGRICULTURE

### (A) Overgrazing

Livestock wealth plays a crucial role in the rural life of our country. India leads in live stock population in the world. The huge population of livestock needs to be fed and the grazing lands or pasture areas are not adequate. Very often we find that the live stock grazing on a particular piece of grassland or pasture surpass the carrying capacity. **Carrying capacity** of any system is the maximum population that can be supported by it on a sustainable basis. However, most often, the grazing pressure is so high that its carrying capacity is crossed and the sustainability of the grazing lands fails. Let us see what are the impacts of overgrazing.

### Impact of Overgrazing

(*i*) **Land Degradation:** Overgrazing removes the vegetal cover over the soil and the exposed soil gets compacted due to which the operative soil depth declines. So the roots cannot go much deep into the soil and adequate soil moisture is not available. Organic recycling also declines in the ecosystem because not enough detritus or litter

remains on the soil to be decomposed. The humus content of the soil decreases and overgrazing leads to organically poor, dry, compacted soil. Due to trampling by cattle the soil loses infiltration capacity, which reduces percolation of water into the soil and as a result of this more water gets lost from the ecosystem along with surface run off. Thus over grazing leads to multiple actions resulting in loss of soil structure, hydraulic conductivity and soil fertility.

(*ii*) **Soil Erosion:** Due to overgrazing by cattle, the cover of vegetation almost gets removed from the land. The soil becomes exposed and gets eroded by the action of strong wind, rainfall etc. The grass roots are very good binders of soil. When the grasses are removed, the soil becomes loose and susceptible to the action of wind and water.

(*iii*) **Loss of useful species:** Overgrazing adversely affects the composition of plant population and their regeneration capacity. The original grassland consists of good quality grasses and forbs with high nutritive value. When the livestock graze upon them heavily, even the root stocks which carry the reserve food for regeneration get destroyed. Now some other species appear in their place. These secondary species are hardier and are less nutritive in nature. Some livestock keep on overgrazing on these species also. Ultimately the nutritious, juicy fodder giving species like *Cenchrus, Dichanthium, Panicum* and *Heteropogon* etc. are replaced by unpalatable and sometimes thorny plants like *Parthenium*, *Lantana, Xanthium* etc. These species do not have a good capacity of binding the soil particles and, therefore, the soil becomes more prone to soil erosion.

As a result of overgrazing vast areas in Arunachal Pradesh and Meghalaya are getting invaded by thorny bushes, weeds etc. of low fodder value. Thus overgrazing makes the grazing land lose its regenerating capacity and once good quality pasture land gets converted into an ecosystem with poor quality thorny vegetation.

**(B) Agriculture**

In the early years of human existence on this earth, man was just a hunter gatherer and was quite like other animal species. Some 10,000 to 12,000 years ago he took to agriculture by cultivating plants of his own choice. He used the practice of **Slash and burn cultivation or shifting cultivation,** which is still prevalent in many tribal areas, as in the North East Hills of India. The type of agriculture practiced these days is very different from the traditional ones and their outputs in terms of yield as well as their impacts on the environment show lots of differences.

**1. Traditional agriculture and its impacts:** It usually involves a small plot, simple tools, naturally available water, organic fertilizer and a mix of crops. It is more near to natural conditions and usually it results in low production. It is still practiced by about half the global population.

The main impacts of this type of agriculture are as follows:

(*i*) **Deforestation:** The slash and burn of trees in forests to clear the land for cultivation and frequent shifting result in loss of forest cover.

(*ii*) **Soil erosion:** Clearing of forest cover exposes the soil to wind, rain and storms, thereby resulting in loss of top fertile layer of soil.

(*iii*) **Depletion of nutrients:** During slash and burn the organic matter in the soil gets destroyed and most of the nutrients are taken up by the crops within a short period, thus making the soil nutrient poor which makes the cultivators shift to another area.

**2. Modern Agriculture and its impacts:** It makes use of hybrid seeds of selected and single crop variety, high-tech equipments and lots of energy subsidies in the form of fertilizers, pesticides and irrigation water. The food production has increased tremendously, evidenced by "green revolution". However, it also gave rise to several problematic off-shoots as discussed below:

(*i*) **Impacts related to high yielding varieties (HYV):** The uses of HYVs encourage monoculture i.e. the same genotype is grown over vast areas. In case of an attack by some pathogen, there is total devastation of the crop by the disease due to exactly uniform conditions, which help in rapid spread of the disease.

(*ii*) **Fertilizer related problems:**

(*a*) **Micronutrient imbalance:** Most of the chemical fertilizers used in modern agriculture have nitrogen, phosphorus and potassium (N, P, K) which are essential macronutrients. Farmers usually use these fertilizers indiscriminately to boost up crop growth. Excessive use of fertilizers cause *micronutrient imbalance*. For example, excessive fertilizer use in Punjab and Haryana has caused deficiency of the micronutrient zinc in the soils, which is affecting productivity of the soil.

(*b*) **Nitrate Pollution:** Nitrogenous fertilizers applied in the fields often leach deep into the soil and ultimately contaminate the ground water. The nitrates get concentrated in the water and when their concentration exceeds 25 mg/L, they become the cause of a serious health hazard called **"Blue Baby Syndrome"** or methaemoglobinemia. This disease affects the

infants to the maximum extent causing even death. In Denmark, England, France, Germany and Netherlands this problem is quite prevalent. In India also, problem of nitrate pollution exists in many areas.

(*c*) **Eutrophication:** Excessive use of N and P fertilizers in the agricultural fields leads to another problem, which is not related to the soil, but relates to water bodies like lakes. A large proportion of nitrogen and phosphorus used in crop fields is washed off and along with runoff water reach the water bodies causing over nourishment of the lakes, a process known as **Eutrophication** (eu=more, trophic=nutrition). Due to eutrophication the lakes get invaded by algal blooms. These algal species grow very fast by rapidly using up the nutrients. They are often toxic and badly affect the food chain. The algal species quickly complete their life cycle and die thereby adding a lot of dead organic matter. The fishes are also killed and there is a lot of dead matter that starts getting decomposed. Oxygen is consumed in the process of decomposition and very soon the water gets depleted of dissolved oxygen. This further affects aquatic fauna and ultimately anaerobic conditions are created where only pathogenic anaerobic bacteria can survive. Thus, due to excessive use of fertilizers in the agricultural fields the lake ecosystem gets degraded. This shows how an unmindful action can have far reaching impacts.

(*iii*) **Pesticide related problems:** Thousands of types of pesticides are used in agriculture. The first generation pesticides include chemicals like sulphur, arsenic, lead or mercury to kill the pests. DDT (Dichlorodiphenyl trichloroethane) whose insecticidal properties were discovered by Paul Mueller in 1939 belongs to the second generation pesticides. After 1940, a large number of synthetic pesticides came into use. Although these pesticides have gone a long way in protecting our crops from huge losses occurring due to pests, yet they have a number of side-effects, as discussed below:

(*a*) **Creating resistance in pests and producing new pests:** Some individuals of the pest species usually survive even after pesticide spray. The survivors give rise to highly resistant generations. About 20 species of pests are now known which have become immune to all types of pesticides and are known as **"Super pests".**

(*b*) **Death of non-target organisms:** Many insecticides are broad spectrum poisons which not only kill the target species but also several non-target species that are useful to us.

(*c*) **Biological magnification:** Many of the pesticides are non-biodegradable and keep on accumulating in the food chain, a process called biological magnification. Since human beings occupy a high trophic level in the food chain, hence they get the pesticides in a bio-magnified form which is very harmful.

(*iv*) **Water Logging:** Over irrigation of croplands by farmers for good growth of their crop usually leads to waterlogging. Inadequate drainage causes excess water to accumulate underground and gradually forms a continuous column with the water table. Under water-logged conditions, pore-spaces in the soil get fully drenched with water and the soil-air gets depleted. The water table rises while the roots of plants do not get adequate air for respiration. Mechanical strength of the soil declines, the crop plants get lodged and crop yield falls.

In Punjab and Haryana, extensive areas have become water-logged where adequate canal water supply or tube-well water encouraged the farmers to use it over- enthusiastically leading to water-logging problem.

Preventing excessive irrigation, sub-surface drainage technology and bio-drainage with trees like Eucalyptus are some of the remedial measures to prevent water-logging.

(*v*) **Salinity problem:** At present one third of the total cultivable land area of the world is affected by salts. In India about seven million hectares of land are estimated to be salt—affected which may be saline or sodic. Saline soils are characterized by the accumulation of soluble salts like sodium chloride, sodium sulphate, calcium chloride, magnesium chloride etc. in the soil profile. Their electrical conductivity is more than 4 dS/m. Sodic soils have carbonates and bicarbonates of sodium, the pH usually exceeds 8.0 and the exchangeable sodium percentage (ESP) is more than 15%.

**Causes:** A Major cause of salinization of soil is excessive irrigation. About 20% of the world's croplands receive irrigation with canal water or ground water which unlike rainwater often contains dissolved salts. Under dry climates, the water evaporates leaving behind salts in the upper soil profile (Fig. 2.4.1)

Thousands of hectares of land area in Haryana and Punjab are affected by soil salinity and alkalinity. Salinity causes stunted plant growth and lowers crop yield. Most of the crops cannot tolerate high salinity.

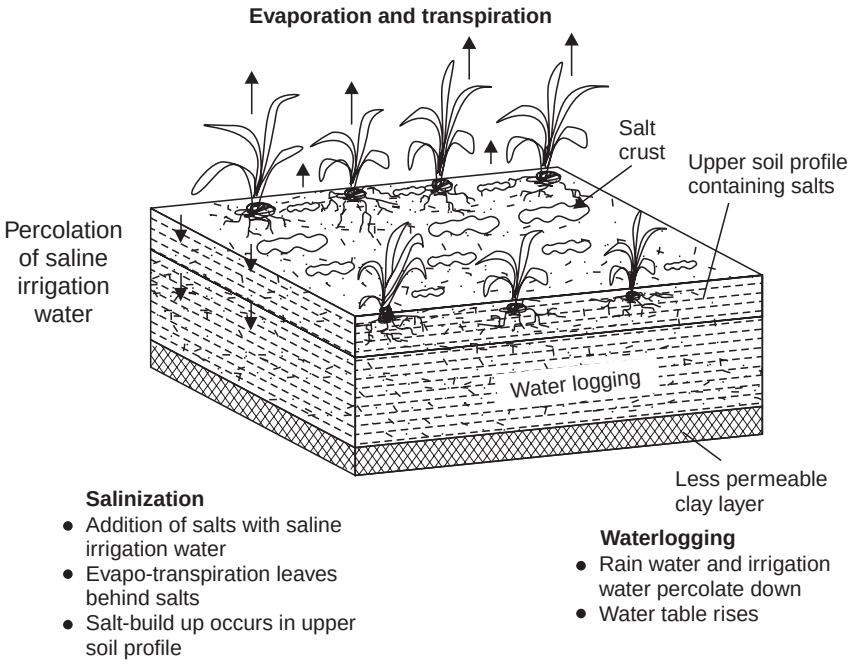

Evaporation and transpiration
Salt crust
Upper soil profile containing salts
Percolation of saline irrigation water
Water logging
Less permeable clay layer
Salinization
• Addition of salts with saline irrigation water
• Evapo-transpiration leaves behind salts
• Salt-build up occurs in upper soil profile
Waterlogging
• Rain water and irrigation water percolate down
• Water table rises

Fig. 2.4.1. Salinization and water logging.

**Remedy:** The most common method for getting rid of salts is to flush them out by applying more good quality water to such soils. Another method is laying underground network of perforated drainage pipes for flushing out the salts slowly. This sub-surface drainage system has been tried in the experimental station of CSSRI at Sampla, Haryana. The Central Soil Salinity Research Institute (CSSRI) located in Karnal, Haryana has to its achievement the success story of converting *Zarifa Viran* village to *Zarifa Abad* i.e. '*from the barren land to productive land*' through its research applications.

## CASE STUDIES

**Salinity and water logging in Punjab, Haryana and Rajasthan :**
The first alarming report of salt-affected wasteland formation in connection with irrigation practices came from Haryana (then Punjab) in 1858. It was reported that several villages in Panipat, Rohtak and Delhi lying in command area of Western Yamuna Canal were suffering from destructive saline efflorescence. The "Reh Committee" in 1886 drew the attention of the government on some vital points showing a close relationship between irrigation, drainage and spread of "reh" and "usar" soils.

*(Contd.)*

The floods of 1947, 1950, 1952, 1954-56 in Punjab resulted in aggravated water logging with serious drainage problems. Introduction of canal irrigation in 1.2 m ha in Haryana resulted in rise in water-table followed by water-logging and salinity in many irrigated areas causing huge economic losses as a result of fall in crop productivity. Rajasthan too has suffered badly in this regard following the biggest irrigation project "Indira Gandhi Canal Project" and the sufferings of a big area in Western Rajasthan have changed from a condition of "water-starved wasteland" to that of a "water soaked wasteland".

## 2.5. ENERGY RESOURCES

Energy consumption of a nation is usually considered as an index of its development. This is because almost all the developmental activities are directly or indirectly dependent upon energy. We find wide disparities in per capita energy use between the developed and the developing nations.

The first form of energy technology probably was the fire, which produced heat and the early man used it for cooking and heating purposes. Wind and hydropower have also been in use for the last 10,000 years. The invention of steam engines replaced the burning of wood by coal and coal was later replaced to a great extent by oil. In 1970's due to Iranian revolution and Arab oil embargo the prices of oil shooted up. This ultimately led to exploration and use of several alternate sources of energy.

### ■ GROWING ENERGY NEEDS

Development in different sectors relies largely upon energy. Agriculture, industry, mining, transportation, lighting, cooling and heating in buildings all need energy. With the demands of growing population the world is facing further energy deficit. The fossil fuels like coal, oil and natural gas which at present are supplying 95% of the commercial energy of the world resources and are not going to last for many more years. Our life style is changing very fast and from a simple way of life we are shifting to a luxurious life style. If you just look at the number of electric gadgets in your homes and the number of private cars and scooters in your locality you will realize that in the last few years they have multiplied many folds and all of them consume energy.

Developed countries like U.S.A. and Canada constitute about 5% of the world's population but consume one fourth of global energy resources. An average person there consumes 300 GJ (Giga Joules, equal to 60 barrels of oils) per year. By contrast, an average man in a poor country like Bhutan, Nepal or Ethiopia consumes less than 1 GJ in a year. So a person in a rich country consumes almost as much energy in a single day as one person does in a whole year in a poor country. This clearly shows that our life-style and standard of living are closely related to energy needs. Fig. 2.5.1 shows the strong correlation between per capita energy use and GNP (Gross National product). U.S.A., Norway, Switzerland etc. with high GNP show high energy use while India, China etc have low GNP and low energy use. Bahrain and Quatar

are oil rich states (UAE) and hence their energy consumption and GNP are more, although their development is not that high.

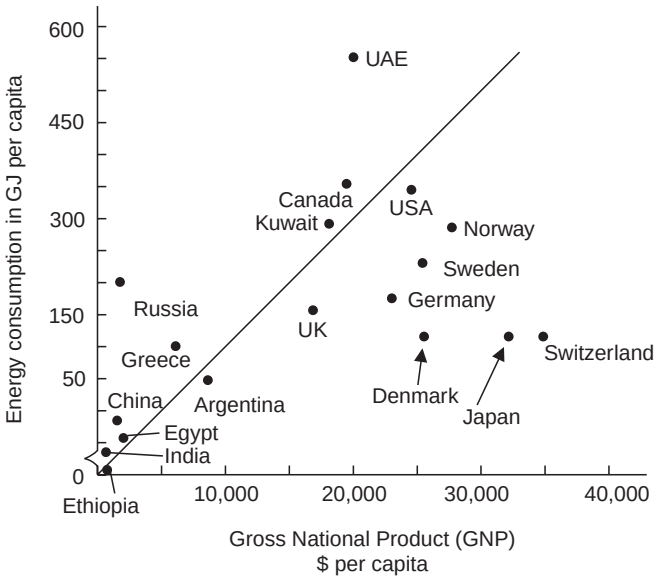



Fig. 2.5.1. Per capita energy use and GNP
(Data from World Resources Institute, 1997)

## ■ RENEWABLE AND NON-RENEWABLE ENERGY SOURCES

A source of energy is one that can provide adequate amount of energy in a usable form over a long period of time. These sources can be of two types:

**(1) Renewable Resources which can be generated continuously in nature and are inexhaustible** e.g. wood, solar energy, wind energy, tidal energy, hydropower, biomass energy, bio-fuels, geo-thermal energy and hydrogen. They are also known as non-conventional sources of energy and they can be used again and again in an endless manner.

**(2) Non-renewable Resources which have accumulated in nature over a long span of time and cannot be quickly replenished when exhausted** e.g. coal, petroleum, natural gas and nuclear fuels like uranium and thorium.

Wood is a renewable resource as we can get new wood by growing a sapling into a tree within 15-20 years but it has taken millions of years for the formation of coal from trees and cannot be regenerated in our life time, hence coal is not renewable. We will now discuss various forms of renewable and non-renewable energy resource.

(*a*) **Renewable Energy Resources**

**Solar energy:** Sun is the ultimate source of energy, directly or indirectly for all other forms of energy. The nuclear fusion reactions occurring inside the sun release enormous quantities of energy in the form of heat and light. The solar energy received by the near earth space is approximately 1.4 kilojoules/second/$m^2$ known as solar constant.

Traditionally, we have been using solar energy for drying clothes and food-grains, preservation of eatables and for obtaining salt from sea-water. Now we have several techniques for harnessing solar energy. Some important solar energy harvesting devices are discussed here.

(*i*) **Solar heat collectors**: These can be passive or active in nature. Passive solar heat collectors are natural materials like stones, bricks etc. or material like glass which absorb heat during the day time and release it slowly at night. Active solar collectors pump a heat absorbing medium (air or water) through a small collector which is normally placed on the top of the building.

(*ii*) **Solar cells:** They are also known as photovoltaic cells or PV cells. Solar cells are made of thin wafers of semi conductor materials like silicon and gallium. When solar radiations fall on them, a potential difference is produced which causes flow of electrons and produces electricity. Silicon can be obtained from silica or sand, which is abundantly available and inexpensive. By using gallium arsenide, cadmium sulphide or boron, efficiency of the PV cells can be improved. The potential difference produced by a single PV cell of 4 $cm^2$ size is about 0.4-0.5 volts and produces a current of 60 milli amperes. Fig. 2.5.2 (*a*) shows the structure of a solar cell.

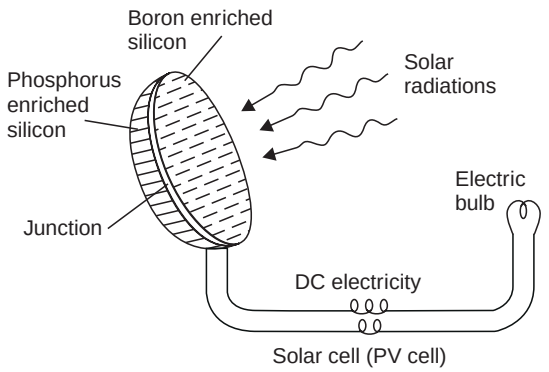



Fig. 2.5.2. (*a*) Solar cell.

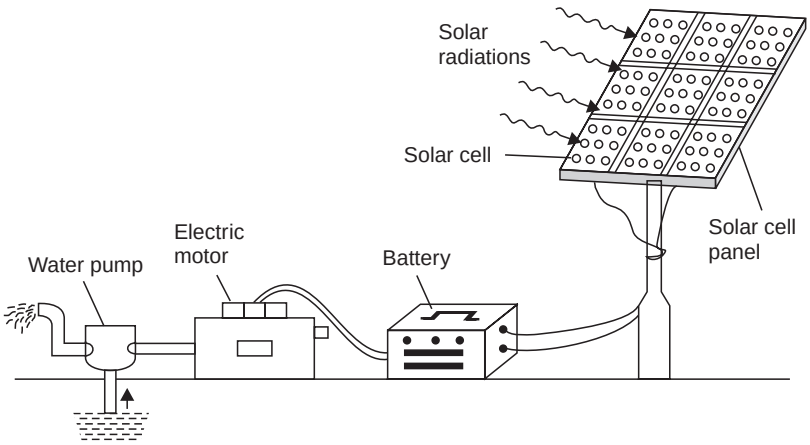



Fig. 2.5.2. (*b*) A solar pump run by electricity produced by solar cells.

A group of solar cells joined together in a definite pattern form a solar panel which can harness a large amount of solar energy and can produce electricity enough to run street-light, irrigation water pump etc. (Fig. 2.5.2).

Solar cells are widely used in calculators, electronic watches, street lighting, traffic signals, water pumps etc. They are also used in artificial satellites for electricity generation. Solar cells are used for running radio and television also. They are more in use in remote areas where conventional electricity supply is a problem.

(*iii*) **Solar cooker:** Solar cookers make use of solar heat by reflecting the solar radiations using a mirror directly on to a glass sheet

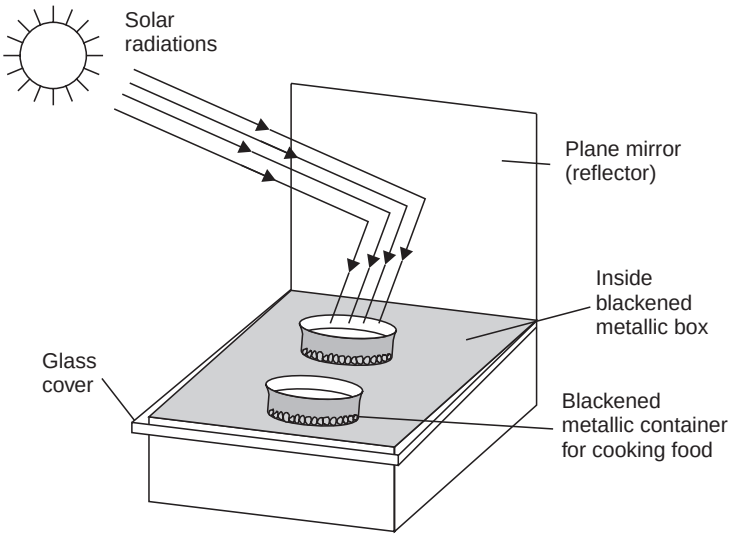



Fig. 2.5.3. Simple box-type solar cooker.

which covers the black insulated box within which the raw food is kept as shown in Fig. 2.5.3. A new design of solar cooker is now available which involves a spherical reflector (concave or parabolic reflector) instead of plane mirror that has more heating effect and hence greater efficiency.

The food cooked in solar cookers is more nutritious due to slow heating. However it has the limitation that it cannot be used at night or on cloudy days. Moreover, the direction of the cooker has to be adjusted according to the direction of the sun rays.

(*iv*) **Solar water heater:** It consists of an insulated box painted black from inside and having a glass lid to receive and store solar heat. Inside the box it has black painted copper coil through which cold water is made to flow in, which gets heated and flows out into a storage tank. The hot water from the storage tank fitted on roof top is then supplied through pipes into buildings like hotels and hospitals.

(*v*) **Solar furnace:** Here thousands of small plane mirrors are arranged in concave reflectors, all of which collect the solar heat and produce as high a temperature as 3000°C.

(*vi*) **Solar power plant:** Solar energy is harnessed on a large scale by using concave reflectors which cause boiling of water to produce steam. The steam turbine drives a generator to produce electricity. A solar power plant (50 K Watt capacity) has been installed at Gurgaon, Haryana.

## ■ WIND ENERGY

The high speed winds have a lot of energy in them as kinetic energy due to their motion. The driving force of the winds is the sun. The wind energy is harnessed by making use of wind mills. The blades of the wind mill keep on rotating continuously due to the force of the striking wind. The rotational motion of the blades drives a number of machines like water pumps, flour mills and electric generators. A large number of wind mills are installed in clusters called **wind farms**, which feed power to the utility grid and produce a large amount of electricity. These farms are ideally located in coastal regions, open grasslands or hilly regions, particularly mountain passes and ridges where the winds are strong and steady. The minimum wind speed required for satisfactory working of a wind generator is **15 km/hr.**

**The wind power potential of our country is estimated to be about 20,000 MW, while at present we are generating about 1020 MW.** The largest wind farm of our country is near Kanyakumari in Tamil Nadu generating 380 MW electricity.

Wind energy is very useful as it does not cause any air pollution. After the initial installation cost, the wind energy is very cheap. It is believed that by the middle of the century wind power would supply more than 10% of world's electricity.

## ■ HYDROPOWER

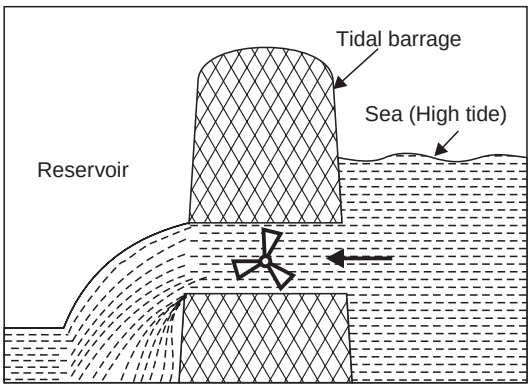
The water flowing in a river is collected by constructing a big dam where the water is stored and allowed to fall from a height. The blades of the turbine located at the bottom of the dam move with the fast moving water which in turn rotate the generator and produces electricity. We can also construct mini or micro hydel power plants on the rivers in hilly regions for harnessing the hydro energy on a small scale, but the minimum height of the water falls should be 10 metres. **The hydropower potential of India is estimated to be about $4 \times 10^{11}$ KW-hours.** Till now we have utilized only a little more than 11% of this potential.

Hydropower does not cause any pollution, it is renewable and normally the hydro power projects are multi-purpose projects helping in controlling floods, used for irrigation, navigation etc. However, big dams are often associated with a number of environmental impacts which have already been discussed in the previous section.

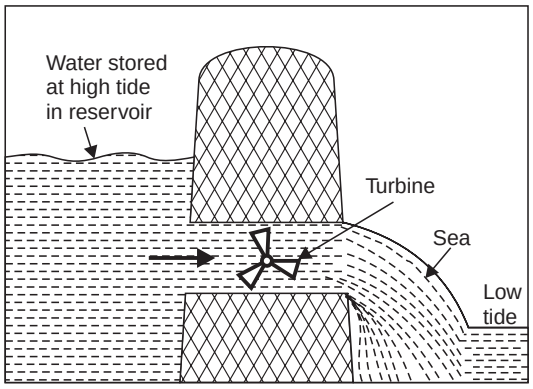
## ■ TIDAL ENERGY

Ocean tides produced by gravitational forces of sun and moon contain enormous amounts of energy. The **'high tide'** and **'low tide'** refer to the rise and fall of water in the oceans. A difference of several meters is required between the height of high and low tide to spin the turbines. The tidal energy can be harnessed by constructing a tidal barrage. During high tide, the sea-water flows into the reservoir of the barrage and turns the turbine, which in turn produces electricity by rotating the generators. During low tide, when the sea-level is low, the sea water stored in the barrage reservoir flows out into the sea and again turns the turbines. (Fig. 2.5.4)

There are only a few sites in the world where tidal energy can be suitably harnessed. The bay of Fundy Canada having 17-18 m high tides has a potential of 5,000 MW of power generation. The tidal mill at La Rance, France is one of the first modern tidal power mill. In India Gulf of Cambay, Gulf of Kutch and the Sunder bans deltas are the tidal power sites.




(a)




(b)

Fig. 2.5.4. Water flows into the reservoir to turn the turbine at high tide (*a*), and flows out from the reservoir to the sea, again turning the turbine at low tide (*b*).

## ■ OCEAN THERMAL ENERGY (OTE)

The energy available due to the difference in temperature of water at the surface of the tropical oceans and at deeper levels is called Ocean Thermal Energy. A difference of 20°C or more is required between surface water and deeper water of ocean for operating OTEC (Ocean Thermal Energy Conversion) power plants. The warm surface water of ocean is used to boil a liquid like ammonia. The high pressure vapours of the liquid formed by boiling are then used to turn the turbine of a generator and produce electricity. The colder water from the deeper oceans is pumped to cool and condense the vapours into liquid. Thus the process keeps on going continuously for 24 hours a day.

## ■ GEOTHERMAL ENERGY

The energy harnessed from the hot rocks present inside the earth is called geothermal energy. High temperature, high pressure steam fields exist below the earth's surface in many places. This heat comes from the fission of radioactive material naturally present in the rocks. In some places, the steam or the hot water comes out of the ground naturally through cracks in the form of **natural geysers** as in Manikaran, Kullu and Sohana, Haryana. Sometimes the steam or boiling water underneath the earth do not find any place to come out. We can artificially drill a hole up to the hot rocks and by putting a pipe in it make the steam or hot water gush out through the pipe at high pressure which turns the turbine of a generator to produce electricty. In USA and New Zealand, there are several geothermal plants working successfully.

## ■ BIOMASS ENERGY

Biomass is the organic matter produced by the plants or animals which include wood, crop residues, cattle dung, manure, sewage, agricultural wastes etc. Biomass energy is of the following types :

(*a*) **Energy Plantations:** Solar energy is trapped by green plants through photosynthesis and converted into biomass energy. Fast growing trees like cottonwood, poplar and *Leucaena*, non-woody herbaceous grasses, crop plants like sugarcane, sweet sorghum and sugar beet, aquatic weeds like water hyacinth and sea-weeds and carbohydrate rich potato, cereal etc. are some of the important energy plantations. They may produce energy either by burning directly or by getting converted into burnable gas or may be converted into fuels by fermentation.

(*b*) **Petro-crops:** Certain latex-containing plants like *Euphorbias* and oil palms are rich in hydrocarbons and can yield an oil like substance under high temperature and pressure. This oily material may be burned in diesel engines directly or may be refined to form gasoline. These plants are popularly known as petro-crops.

(*c*) **Agricultural and Urban Waste biomass:** Crop residues, bagasse (sugarcane residues), coconut shells, peanut hulls, cotton stalks etc. are some of the common agricultural wastes which produce energy by burning. Animal dung, fishery and poultry waste and even human refuse are examples of biomass energy. In Brazil 30 % of electricity is obtained from burning bagasse. In rural India, animal dung cakes are burnt to produce heat. About 80 % of rural heat energy requirements are met by burning agricultural wastes, wood and animal dung cakes.

In rural areas these forms of waste biomass are burned in open furnaces called '**Chulhas**' which usually produce smoke and are not so efficient (efficiency is <8 %). Now improved Chulhas with tall chimney have been designed which have high efficiency and are smokeless.

The burning of plant residues or animal wastes cause air pollution and produce a lot of ash as waste residue. The burning of dung destroys essential nutrients like N and P. It is therefore, more useful to convert the biomass into biogas or bio fuels.

## ■ BIOGAS

Biogas is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide, the major constituent being methane. Biogas is produced by anaerobic degradation of animal wastes (sometimes plant wastes) in the presence of water. Anaerobic degradation means break down of organic matter by bacteria in the absence of oxygen.

Biogas is a non-polluting, clean and low cost fuel which is very useful for rural areas where a lot of animal waste and agricultural waste are available. India has the largest cattle population in the world (240 million) and has tremendous potential for biogas production. From cattle dung alone, we can produce biogas of a magnitude of 22,500 $Mm^3$ annually. A sixty cubic feet gobar gas plant can serve the needs of one average family.

Biogas has the following main advantages : It is clean, non-polluting and cheap. There is direct supply of gas from the plant and there is no storage problem. The sludge left over is a rich fertilizer containing bacterial biomass with most of the nutrients preserved as such. Air-tight digestion/degradation of the animal wastes is safe as it eliminates health hazards which normally occur in case of direct use of dung due to direct exposure to faecal pathogens and parasites.

Biogas plants used in our country are basically of two types:

1. Floating gas-holder type and 2. Fixed-dome type.

**1. Floating gas holder type biogas plant:** This type has a well-shaped digester tank which is placed under the ground and made up of bricks. In the digester tank, over the dung slurry an inverted steel drum floats to hold the bio-gas produced. The gas holder can move which is controlled by a pipe and the gas outlet is regulated by a valve. The digester tank has a partition wall and one side of it receives the dung-water mixture through inlet pipe while the other side discharges the spent slurry through outlet pipe. (Fig 2.5.5)

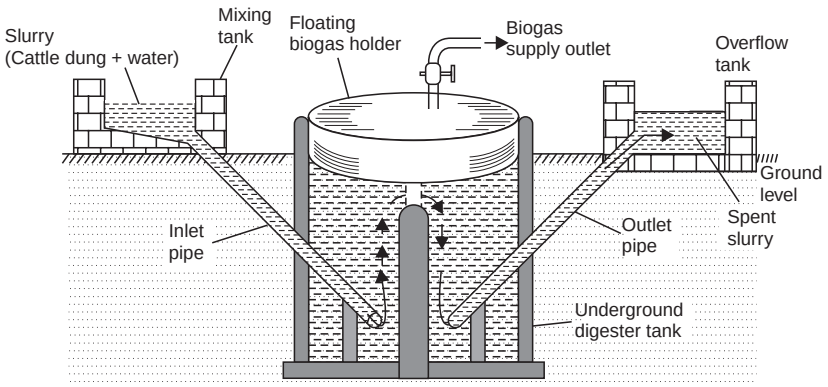



Fig. 2.5.5. Floating gas holder type biogas plant.

Sometimes corrosion of steel gas-holder leads to leakage of biogas. The tank has to be painted time and again for maintenance which increases the cost. Hence another type was designed as discussed below :

**2. Fixed dome type biogas plant:** The structure is almost similar to that of the previous type. However, instead of a steel gas-holder there is dome shaped roof made of cement and bricks. Instead of partitioning, here there is a single unit in the main digester but it has inlet and outlet chambers as shown in Fig 2.5.6.

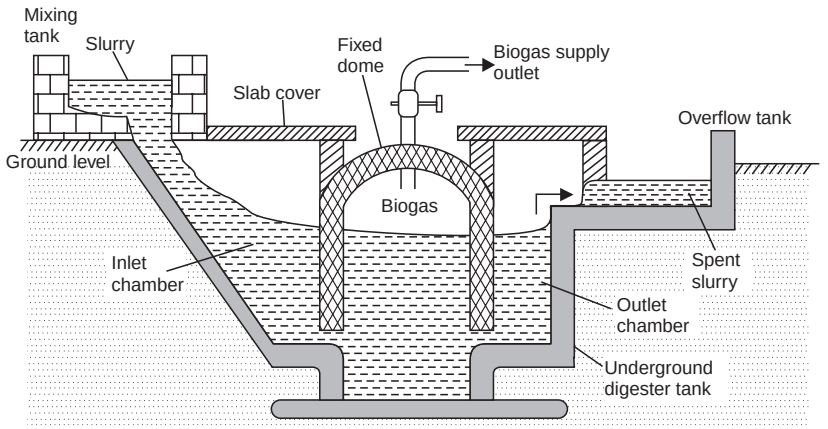



Fig. 2.5.6. Fixed dome type Biogas plant.

The Ministry of Non-Conventional Energy Sources (MNES) has been promoting the Biogas Programme in India. Out of the various models, the important ones used in rural set-up are KVIC Model

(Floating drum type), Janta Model (Fixed dome type), Deenbandhu Model (Fixed dome type), Pragati Model (floating drum type), Ganesh Model (KVIC type but made of bamboo and polythene sheet) and Ferro-cement digester Model (KVIC type with ferro-cement digester).

## ■ BIOFUELS

Biomass can be fermented to alcohols like ethanol and methanol which can be used as fuels. Ethanol can be easily produced from carbohydrate rich substances like sugarcane. It burns clean and is non-polluting. However, as compared to petrol its calorific value is less and therefore, produces much less heat than petrol.

**Gasohol** is a common fuel used in Brazil and Zimbabwe for running cars and buses. In India too gasohol is planned to be used on trial basis in some parts of the country, to start with in Kanpur. Gasohol is a mixture of ethanol and gasoline.

**Methanol** is very useful since it burns at a lower temperature than gasoline or diesel. Thus the bulky radiator may be substituted by sleek designs in our cars. Methanol too is a clean, non-polluting fuel.

Methanol can be easily obtained from woody plants and ethanol from grain-based or sugar-containing plants.

## ■ HYDROGEN AS A FUEL

As hydrogen burns in air, it combines with oxygen to form water and a large amount of energy (150 kilojoules per gram) is released. Due to its high, rather the highest calorific value, hydrogen can serve as an excellent fuel. Moreover, it is non-polluting and can be easily produced. Production of Hydrogen is possible by thermal dissociation, photolysis or electrolysis of water:

(*i*) By thermal dissociation of water (at 3000°K or above) hydrogen ($H_2$) is produced.

(*ii*) Thermochemically, hydrogen is produced by chemical reaction of water with some other chemicals in 2-3 cycles so that we do not need the high temperatures as in direct thermal method and ultimately $H_2$ is produced.

(*iii*) Electrolytic method dissociates water into hydrogen ($H_2$) and oxygen by making a current flow through it.

(*iv*) Photolysis of water involves breakdown of water in the presence of sun light to release hydrogen. Green plants also have photolysis of water during photosynthesis. Efforts are underway to trap hydrogen molecule which is produced during photosynthesis.

However, hydrogen is highly inflammable and explosive in nature. Hence, safe handling is required for using $H_2$ as a fuel. Also, it is difficult to store and transport. And, being very light, it would have to be stored in bulk.

Presently, $H_2$ is used in the form of liquid hydrogen as a fuel in spaceships.

(*b*) **Non-Renewable Energy Sources**

These are the fossil fuels like coal, petroleum, natural gas and nuclear fuels. These were formed by the decomposition of the remains of plants and animals buried under the earth millions of years ago. The fuels are very precious because they have taken such a long time to be formed and if we exhaust their reserves at such a fast rate as we have been doing, ever since we discovered them, then very soon we will lose these resources forever.

## ■ COAL

Coal was formed 255-350 million years ago in the hot, damp regions of the earth during the carboniferous age. The ancient plants along the banks of rivers and swamps were buried after death into the soil and due to the heat and pressure gradually got converted into peat and coal over millions of years of time. There are mainly three types of coal, namely ***anthracite*** (hard coal), ***bituminous*** (Soft coal) and ***lignite*** (brown coal). Anthracite coal has maximum carbon (90%) and calorific value (8700 kcal/kg.) Bituminous, lignite and peat contain 80, 70 and 60% carbon, respectively. Coal is the most abundant fossil fuel in the world. ***At the present rate of usage, the coal reserves are likely to last for about 200 years and if its use increases by 2% per year, then it will last for another 65 years.***

India has about 5% of world's coal and Indian coal is not very good in terms of heat capacity. Major coal fields in India are Raniganj, Jharia, Bokaro, Singrauli, and Godavari valley. The coal states of India are Jharkhand, Orissa, West Bengal, Madhya Pradesh, Andhra Pradesh and Maharashtra. Anthracite coal occurs only in J & K.

When coal is burnt it produces carbon dioxide, which is a greenhouse gas responsible for causing enhanced global warming. Coal also contains impurities like sulphur and therefore as it burns the smoke contains toxic gases like oxides of sulphur and nitrogen.

## ■ PETROLEUM

It is the lifeline of global economy. There are 13 countries in the world having 67% of the petroleum reserves which together form the

OPEC (Organization of Petroleum exporting countries). About 1/4th of the oil reserves are in Saudi Arabia.

At the present rate of usage, the world's crude oil reserves are estimated to get exhausted in just 40 years. Some optimists, however, believe that there are some yet undiscovered reserves. Even then the crude oil reserves will last for another 40 years or so. Crude petroleum is a complex mixture of alkane hydrocarbons. Hence it has to be purified and refined by the process of *fractional distillation*, during which process different constituents separate out at different temperatures. We get a large variety of products from this, namely, petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax, asphalt, plastic etc.

Petroleum is a cleaner fuel as compared to coal as it burns completely and leaves no residue. It is also easier to transport and use. That is the reason why petroleum is preferred amongst all the fossil fuels.

**Liquefied petroleum gas (LPG):** The main component of petroleum is butane, the other being propane and ethane. The petroleum gas is easily converted to liquid form under pressure as LPG. It is odourless, but the LPG in our domestic gas cylinders gives a foul smell. This is, in fact, due to ethyl mercaptan, a foul smelling gas, added to LPG so that any leakage of LPG from the cylinder can be detected instantaneously.

Oil fields in India are located at Digboi (Assam), Gujarat Plains and Bombay High, offshore areas in deltaic coasts of Gadavari, Krishna, Kaveri and Mahanadi.

## ■ NATURAL GAS

It is mainly composed of methane (95%) with small amounts of propane and ethane. It is a fossil fuel. Natural gas deposits mostly accompany oil deposits because it has been formed by decomposing remains of dead animals and plants buried under the earth. **Natural gas is the cleanest fossil fuel.** It can be easily transported through pipelines. It has a high calorific value of about 50KJ/G and burns without any smoke.

Currently, the amount of natural gas deposits in the world are of the order of 80, 450 g $m^{-3}$. Russia has maximum reserves (40%), followed by Iran (14%) and USA (7%). Natural gas reserves are found in association with all the oil fields in India. Some new gas fields have been found in Tripura, Jaisalmer, Off-shore area of Mumbai and the Krishna Godavari Delta.

Natural gas is used as a domestic and industrial fuel. It is used as a fuel in thermal power plants for generating electricity. It is used as a source of hydrogen gas in fertilizer industry and as a source of carbon in tyre industry.

**Compressed natural gas (CNG):** It is being used as an alternative to petrol and diesel for transport of vehicles. Delhi has totally switched over to CNG where buses and auto rickshaws run on this new fuel. CNG use has greatly reduced vehicular pollution in the city.

**Synthetic natural gas (SNG):** It is a mixture of carbon monoxide and hydrogen. It is a connecting link between a fossil fuel and substituted natural gas. Low grade coal is initially transformed into synthetic gas by gasification followed by catalytic conversion to methane.

## ■ NUCLEAR ENERGY

Nuclear energy is known for its high destructive power as evidenced from nuclear weapons. The nuclear energy can also be harnessed for providing commercial energy. Nuclear energy can be generated by two types of reactions:

(*i*) *Nuclear Fission*: It is the nuclear change in which nucleus of certain isotopes with large mass numbers are split into lighter nuclei on bombardment by neutrons and a large amount of energy is released through a chain reaction as shown in Fig. 2.5.7 (*a*).

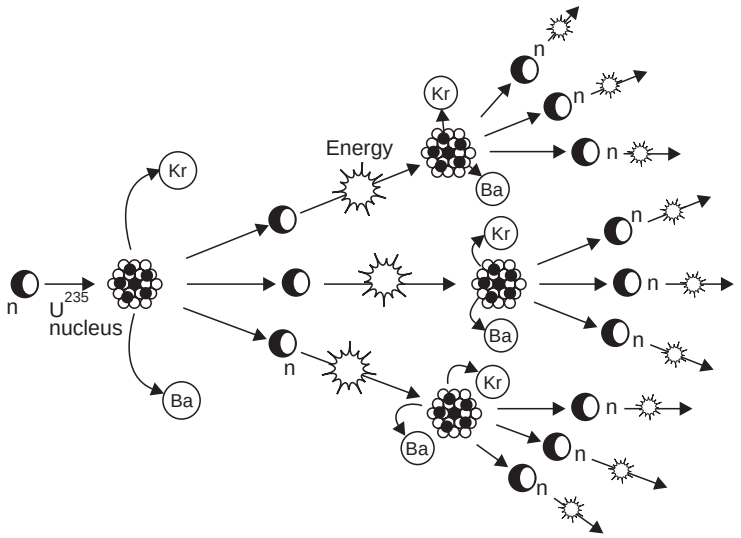



Fig. 2.5.7. (*a*) Nuclear fission—a chain reaction initiated by one neutron that bombards a Uranium ($U^{235}$) nucleus, releasing a huge quantity of energy, two smaller nuclei (Ba, Kr) and 3 neutrons.

$$_{92}U^{235} + {}_{0}n^{1} \longrightarrow {}_{36}Kr^{92} + {}_{56}Ba^{141} + 3\ {}_{0}n^{1} + \text{Energy}$$

Nuclear Reactors make use of nuclear chain reaction. In order to control the rate of fission, only 1 neutron released is allowed to strike for splitting another nucleus. Uranium-235 nuclei are most commonly used in nuclear reactors.

(*ii*) *Nuclear fusion*: Here two isotopes of a light element are forced together at extremely high temperatures (1 billion °C) until they fuse to form a heavier nucleus releasing enormous energy in the process. It is difficult to initiate the process but it releases more energy than nuclear fission. (Fig. 2.5.7 (*b*))

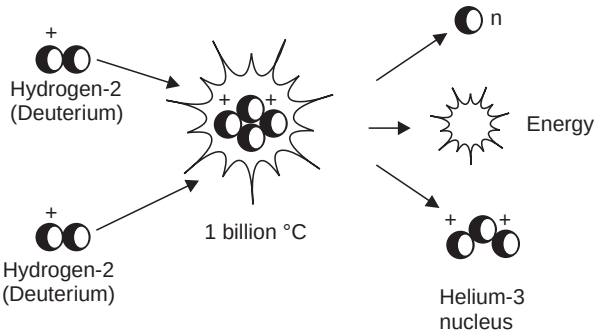



Fig. 2.5.7. (*b*) Nuclear fusion reaction between two hydrogen-2 nuclei, which take place at a very high temperature of 1 billion °C; one neutron and one fusion nucleus of helium-3 is formed along with a huge amount of energy.

$$_{1}H^{2} + {}_{1}H^{2} \longrightarrow {}_{3}He^{2} + {}_{0}n^{1} + \text{Energy}$$

Two hydrogen-2 (Deuterium) atoms may fuse to form the nucleus of Helium at 1 billion °C and release a huge amount of energy. Nuclear fusion reaction can also take place between one Hydrogen-2 (Deuterium) and one Hydrogen-3 (Tritium) nucleus at 100 million °C forming Helium-4 nucleus, one neutron and a huge amount of energy.

Nuclear energy has tremendous potential but any leakage from the reactor may cause devastating nuclear pollution. Disposal of the nuclear waste is also a big problem.

Nuclear power in India is still not very well developed. There are four nuclear power stations with an installed capacity of 2005 MW.

These are located at Tarapur (Maharashtra), Rana Pratap Sagar near Kota (Rajasthan), Kalpakkam (Tamil Nadu) and Narora (U.P.).

# 2.6. LAND RESOURCES

## ■ LAND AS A RESOURCE

Land is a finite and valuable resource upon which we depend for our food, fibre and fuel wood, the basic amenities of life. Soil, especially the top soil, is classified as a renewable resource because it is continuously regenerated by natural process though at a very slow rate. About 200-1000 years are needed for the formation of one inch or 2.5 cm soil, depending upon the climate and the soil type. But, when rate of erosion is faster than rate of renewal, then the soil becomes a non-renewable resource.

## ■ LAND DEGRADATION

With increasing population growth the demands for arable land for producing food, fibre and fuel wood is also increasing. Hence there is more and more pressure on the limited land resources which are getting degraded due to over-exploitation. Soil degradation is a real cause of alarm because soil formation is an extremely slow process as discussed above and the average annual erosion rate is 20-100 times more than the renewal rate.

Soil erosion, water-logging, salinization and contamination of the soil with industrial wastes like fly-ash, press-mud or heavy metals all cause degradation of land.

## ■ SOIL EROSION

The literal meaning of 'soil erosion' is wearing away of soil. Soil erosion is defined as the movement of soil components, especially surface-litter and top soil from one place to another. Soil erosion results in the loss of fertility because it is the top soil layer which is fertile. If we look at the world situation, we find that one third of the world's cropland is getting eroded. Two thirds of the seriously degraded lands lie in Asia and Africa.

Soil erosion is basically of two types based upon the cause of erosion:

(*i*) **Normal erosion or geologic erosion:** caused by the gradual removal of top soil by natural processes which bring an equilibrium between physical, biological and hydrological activities and maintain a natural balance between erosion and renewal.

(*ii*) **Accelerated erosion:** This is mainly caused by anthropogenic (man-made) activities and the rate of erosion is much faster than the rate of formation of soil. Overgrazing, deforestation and mining are some important activities causing accelerated erosion.

There are two types of agents which cause soil erosion:

(*i*) **Climatic agents:** water and wind are the climatic agents of soil erosion. Water affects soil erosion in the form of torrential rains, rapid flow of water along slopes, run-off, wave action and melting and movement of snow.

**Water induced soil erosion** is of the following types:

- ***Sheet erosion:*** when there is uniform removal of a thin layer of soil from a large surface area, it is called sheet erosion. This is usually due to run-off water.
- ***Rill erosion:*** When there is rainfall and rapidly running water produces finger-shaped grooves or rills over the area, it is called rill erosion.
- ***Gully erosion:*** It is a more prominent type of soil erosion. When the rainfall is very heavy, deeper cavities or gullies are formed, which may be U or V shaped.
- ***Slip erosion:*** This occurs due to heavy rainfall on slopes of hills and mountains.
- ***Stream bank erosion:*** During the rainy season, when fast running streams take a turn in some other direction, they cut the soil and make caves in the banks.

**Wind erosion** is responsible for the following three types of soil movements:

- ***Saltation:*** This occurs under the influence of direct pressure of stormy wind and the soil particles of 1-1.5 mm diameter move up in vertical direction.
- ***Suspension:*** Here fine soil particles (less than 1 mm dia) which are suspended in the air are kicked up and taken away to distant places.
- ***Surface creep:*** Here larger particles (5-10 mm diameter) creep over the soil surface along with wind.

(*ii*) **Biotic agents:** Excessive grazing, mining and deforestation are the major biotic agents responsible for soil erosion. Due to these processes the top soil is disturbed or rendered devoid of vegetation cover. So the land is directly exposed to the action of various physical forces facilitating erosion. Overgrazing accounts for 35% of the world's soil

erosion while deforestation is responsible for 30% of the earth's seriously eroded lands. Unsustainable methods of farming cause 28% of soil erosion.

Deforestation without reforestation, overgrazing by cattle, surface mining without land reclamation, irrigation techniques that lead to salt build-up, water-logged soil, farming on land with unsuitable terrain, soil compaction by agricultural machinery, action of cattle trampling etc make the top soil vulnerable to erosion.

### Soil Conservation Practices

In order to prevent soil erosion and conserve the soil the following conservation practices are employed:

(*i*) **Conservational till farming:** In traditional method the land is ploughed and the soil is broken up and smoothed to make a planting surface. However, this disturbs the soil and makes it susceptible to erosion when fallow (i.e. without crop cover). Conservational till farming, popularly known as **no-till-farming** causes minimum disturbance to the top soil. Here special tillers break up and loosen the subsurface soil without turning over the topsoil. The tilling machines make slits in the unploughed soil and inject seeds, fertilizers, herbicides and a little water in the slit, so that the seed germinates and the crop grows successfully without competition with weeds.

(*ii*) **Contour farming:** On gentle slopes, crops are grown in rows across, rather than up and down, a practice known as contour farming. Each row planted horizontally along the slope of the land acts as a small dam to help hold soil and slow down loss of soil through run-off water.

(*iii*) **Terracing:** It is used on still steeper slopes are converted into a series of broad terraces which run across the contour. Terracing retains water for crops at all levels and cuts down soil erosion by controlling run off. In high rainfall areas, ditches are also provided behind the terrace to permit adequate drainage (Plate I, *a*).

(*iv*) **Strip cropping:** Here strips of crops are alternated with strips of soil saving covercrops like grasses or grass-legume mixture. Whatever run-off comes from the cropped soil is retained by the strip of covercrop and this reduces soil erosion. Nitrogen fixing legumes also help in restoring soil fertility (Plate I, *b*).

Plate I(a) Terrace farming

Plate I(b) Strip cropping

(*vi*) **Alley cropping:** It is a form of inter-cropping in which crops are planted between rows of trees or shrubs. This is also called **Agro forestry.** Even when the crop is harvested, the soil is not fallow because trees and shrubs still remain on the soil holding the soil particles and prevent soil erosion (Plate I, *c*).

**Wind breaks or shelterbelts:** They help in reducing erosion caused by strong winds. The trees are planted in long rows along the cultivated land boundary so that wind is blocked. The wind speed is substantially reduced which helps in preventing wind erosion of soil (Plate I, *d*).

Plate I(c) Alley cropping

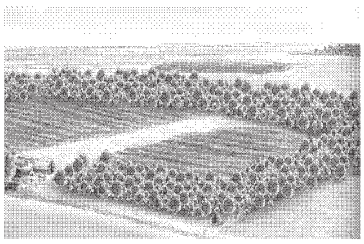


Plate I(d) Shelter belt

Thus, soil erosion is one of the world's most critical problems and, if not slowed, will seriously reduce agricultural and forestry production, and degrade the quality of aquatic ecosystems as well due to increased siltation. Soil erosion, is in fact, a gradual process and very often the cumulative effects becomes visible only when the damage has already become irreversible. The best way to control soil erosion is to maintain adequate vegetational cover over the soil.

### Water Logging

In order to provide congenial moisture to the growing crops, farmers usually apply heavy irrigation to their farmland. Also, in order to leach down the salts deeper into the soil, the farmer provides more irrigation

water. However, due to inadequate drainage and poor quality irrigation water there is accumulation of water underground and gradually it forms a continuous column with the water table. We call these soils as waterlogged soils which affect crop growth due to inhibition of exchange of gases. The pore-spaces between the soil particles get fully drenched with water through the roots.

Water logging is most often associated with salinity because the water used for irrigation contains salts and the soils get badly degraded due to erroneous irrigation practices. The damages caused by some major irrigation projects is shown is Table 2.6.1.

**Table 2.6.1. Water logging and salinisation caused due to some irrigation projects in India**

| Irrigation Project | State | Area affected (thousand hectares) | |
|---|---|---|---|
| | | Water logging | Salinity |
| Indira Gandhi Canal | Rajasthan | 43 | 29 |
| Gandak | Bihar, Gujarat | 211 | 400 |
| Chambal | M.P., Rajasthan | 98 | 40 |
| Ram Ganga | U.P. | 195 | 352 |
| Sri Ram Sagar | Andhra Pradesh | 60 | 1 |

*Source :* B.K. Garg and I.C. Gupta (1997).*

An estimated loss of Rs. 10,000 million per annum occurs due to water-logging and salinity in India. It is a startling fact because the cost of development of the irrigation projects is very high and in the long run they cause problems like water logging and salinity thereby sharply reducing soil fertility.

## ■ LANDSLIDES

Various anthropogenic activities like hydroelectric projects, large dams, reservoirs, construction of roads and railway lines, construction of buildings, mining etc are responsible for clearing of large forested areas. Earlier there were few reports of landslides between Rishikesh and Byasi on Badrinath Highway area. But, after the highway was constructed, 15 landslides occurred in a single year. During construction of roads,

*Saline Wastelands, Environment and Plant Growth. Sci. Publ., India.

mining activities etc. huge portions of fragile mountainous areas are cut or destroyed by dynamite and thrown into adjacent valleys and streams. These land masses weaken the already fragile mountain slopes and lead to landslides. They also increase the turbidity of various nearby streams, thereby reducing their productivity.

## ■ DESERTIFICATION

Desertification is a process whereby the productive potential of arid or semiarid lands falls by ten percent or more. Moderate desertification is 10-25% drop in productivity, severe desertification causes 25-50% drop while very severe desertification results in more than 50% drop in productivity and usually creates huge gullies and sand dunes. Desertification leads to the conversion of rangelands or irrigated croplands to desert like conditions in which agricultural productivity falls. Desertification is characterized by devegetation and loss of vegetal over, depletion of groundwater, salinization and severe soil erosion. Desertification is not the literal invasion of desert into a non-desert area. It includes degradation of the ecosystems within as well as outside the natural deserts. The Sonoran and Chihuahuan deserts are about a million years old, yet they have become more barren during the last 100 years. So, further desertification has taken place within the desert.

**Causes of Desertification:** Formation of deserts may take place due to natural phenomena like climate change or may be due to abusive use of land. Even the climate change is linked in many ways to human activities. The major anthropogenic activities responsible for desertification are as follows:

(*a*) **Deforestation:** The process of denuding and degrading a forested land initiates a desert producing cycle that feeds on itself. Since there is no vegetation to hold back the surface run-off, water drains off quickly before it can soak into the soil to nourish the plants or to replenish the groundwater. This increases soil erosion, loss of fertility and loss of water.

(*b*) **Overgrazing**: The regions most seriously affected by desertification are the cattle producing areas of the world. This is because the increasing cattle population heavily graze in grasslands or forests and as a result denude the land area. When the earth is denuded, the microclimate near the ground becomes inhospitable to seed germination. The dry barren land becomes loose and more prone to soil erosion. The top fertile layer is also lost and thus plant growth is badly hampered in such soils. The dry barren land reflects more of the

sun's heat, changing wind patterns, driving away moisture laden clouds leading to further desertification.

(*c*) **Mining and quarrying:** These activities are also responsible for loss of vegetal cover and denudation of extensive land areas leading to desertification. Deserts are found to occur in the arid and semi-arid areas of all the continents . During the last 50 years about 900 million hectares of land have undergone desertification over the world. This problem is especially severe in Sahel region, just south of the Sahara in Africa. It is further estimated that if desertification continues at the present rate, then by 2010, it will affect such lands which are presently occupied by 20% of the human population.

Amongst the most badly affected areas are the sub Saharan Africa, the Middle East, Western Asia, parts of Central and South America, Australia and the Western half of the United States.

It is estimated that in the last 50 years, human activities have been responsible for desertification of land area equal to the size of Brazil. The UNEP estimates suggest that if we don't make sincere efforts now then very soon 63% of rangelands, 60% of rain-fed croplands and 30% of irrigated croplands will suffer from desertification on a worldwide scale, adding 60,000 $Km^2$ of deserts every year.

## ■ CONSERVATION OF NATURAL RESOURCES: ROLE OF AN INDIVIDUAL

Different natural resources like forests, water, soil, food, mineral and energy resources play a vital role in the development of a nation. However, overuse of these resources in our modern society is resulting in fast depletion of these resources and several related problems. If we want our mankind to flourish there is a strong need to conserve these natural resources.

While conservation efforts are underway at National as well as International level, the individual efforts for conservation of natural resources can go a long way. Environment belongs to each one of us and all of us have a responsibility to contribute towards its conservation and protection. "Small droplets of water together form a big ocean". Similarly, with our small individual efforts we can together help in conserving our natural resources to a large extent. Let us see how can individuals help in conservation of different resources.

### Conserve Water

- Don't keep water taps running while brushing, shaving, washing or bathing.

- In washing machines fill the machine only to the level required for your clothes.
- Install water-saving toilets that use not more than 6 liters per flush.
- Check for water leaks in pipes and toilets and repair them promptly. A small pin-hole sized leak will lead to the wastage of 640 liters of water in a month.
- Reuse the soapy water of washings from clothes for washing off the courtyards, driveways etc.
- Water the plants in your kitchen-garden and the lawns in the evening when evaporation losses are minimum. Never water the plants in mid-day.
- Use drip irrigation and sprinkling irrigation to improve irrigation efficiency and reduce evaporation.
- Install a small system to capture rain water and collect normally wasted used water from sinks, cloth-washers, bath-tubs etc. which can be used for watering the plants.
- Build rain water harvesting system in your house. Even the President of India is doing this.

**Conserve energy**

- Turn off lights, fans and other appliances when not in use.
- Obtain as much heat as possible from natural sources. Dry the clothes in sun instead of drier if it is a sunny day.
- Use solar cooker for cooking your food on sunny days which will be more nutritious and will cut down on your LPG expenses.
- Build your house with provision for sunspace which will keep your house warmer and will provide more light.
- Grow deciduous trees and climbers at proper places outside your home to cut off intense heat of summers and get a cool breeze and shade. This will cut off your electricity charges on coolers and air-conditioners. A big tree is estimated to have a cooling effect equivalent to five air conditioners. The deciduous trees shed their leaves in winter. Therefore they do not put any hindrance to the sunlight and heat.
- Drive less, make fewer trips and use public transportations whenever possible. You can share by joining a car-pool if you regularly have to go to the same place.

- Add more insulation to your house. During winter close the windows at night. During summer close the windows during days if using an A.C. Otherwise loss of heat would be more, consuming more electricity.
- Instead of using the heat convector more often wear adequate woolens.
- Recycle and reuse glass, metals and paper.
- Try riding bicycle or just walk down small distances instead of using your car or scooter.
- Lower the cooling load on an air conditioner by increasing the thermostat setting as 3-5 % electricity is saved for every one degree rise in temperature setting.

**Protect the soil**

- While constructing your house, don't uproot the trees as far as possible. Plant the disturbed areas with a fast growing native ground cover.
- Grow different types of ornamental plants, herbs and trees in your garden. Grow grass in the open areas which will bind the soil and prevent its erosion.
- Make compost from your kitchen waste and use it for your kitchen-garden or flower-pots.
- Do not irrigate the plants using a strong flow of water, as it would wash off the soil.
- Better use sprinkling irrigation.
- Use green manure and mulch in the garden and kitchen-garden which will protect the soil.
- If you own agricultural fields, do not over-irrigate your fields without proper drainage to prevent water logging and salinisation.
- Use mixed cropping so that some specific soil nutrients do not get depleted.

**Promote Sustainable Agriculture**

- Do not waste food. Take as much as you can eat.
- Reduce the use of pesticides.
- Fertilize your crop primarily with organic fertilizers.
- Use drip irrigation to water the crops.
- Eat local and seasonal vegetables. This saves lot of energy on transport, storage and preservation.

- Control pests by a combination of cultivation and biological control methods.

## ■ EQUITABLE USE OF RESOURCES FOR SUSTAINABLE LIFE STYLE

There is a big divide in the world as North and South, the more developed countries (MDC's) and less developed countries (LDC's), the haves and the have nots. The less developed does not mean that they are backward as such, they are culturally very rich or even much more developed, but economically they are less developed. The gap between the two is mainly because of population and resources.

The MDC's have only 22% of world's population, but they use 88% of its natural resources, 73% of its energy and command 85% of its income. In turn, they contribute a very big proportion to its pollution. These countries include USA, Canada, Japan, the CIS, Australia , New Zealand and Western European Countries. The LDC's, on the other hand, have very low or moderate industrial growth, have 78% of the world's population and use about 12% of natural resources and 27% of energy. Their income is merely 15% of global income. The gap between the two is increasing with time due to sharp increase in population in the LDC's. The rich have grown richer while the poor have stayed poor or gone even poorer.

As the rich nations are developing more, they are also leading to more pollution and sustainability of the earth's life support system is under threat. The poor nations, on the other hand, are still struggling hard with their large population and poverty problems. Their share of resources is too little leading to unsustainability.

As the rich nations continue to grow, they will reach a limit. If they have a growth rate of 10 % every year, they will show 1024 times increase in the next 70 years. Will this much of growth be sustainable? The answer is 'No' because many of our earth's resources are limited and even the renewable resources will become unsustainable if their use exceeds their regeneration.

Thus, the solution to this problem is to have more equitable distribution of resources and wealth. We cannot expect the poor countries to stop growth in order to check pollution because development brings employment and the main problem of these countries is to tackle poverty. A global consensus has to be reached for more balanced distribution of the basic resources like safe drinking water, food, fuel etc. so that the poor in the LDC's are at least able to sustain their life. Unless they are provided with such basic resources,

we cannot think of rooting out the problems related to dirty, unhygienic, polluted, disease infested settlements of these people-which contribute to unsustainability.

Thus, the two basic causes of unsustainability are over population in poor countries who have under consumption of resources and over consumption of resources by the rich countries, which generate wastes. In order to achieve sustainable life styles it is desirable to achieve a more balanced and equitable distribution of global resources and income to meet everyone's basic needs.

The rich countries will have to lower down their consumption levels while the bare minimum needs of the poor have to be fulfilled by providing them resources. A fairer sharing of resources will narrow down the gap between the rich and the poor and will lead to sustainable development for all and not just for a privileged group.

## QUESTIONS

1. What are renewable and non-renewable resources ? Give examples.
2. Discuss the major uses of forests. How would you justify that ecological uses of forests surpass commercial uses ?
3. What are the major causes and consequences of deforestation ?
4. Discuss with the help of a case study, how big dams have affected forests and the tribals.
5. What is an aquifer ? Discuss its types.
6. What are the environmental impacts of ground water usage ?
7. Briefly discuss droughts and floods with respect is their occurrence and impacts.
8. What are the major causes for conflicts over water ? Discuss one international and one inter-state water conflict.
9. Should we build big dams ? Give arguments in favour of your answer.
10. What are the uses of various types of minerals ?
11. Discuss the major environmental impacts of mineral extraction.
12. What is overgrazing ? How does it contribute to environmental degradation ?
13. What do your mean by (*a*) eutrophication (*b*) super pest (*c*) shifting cultivation (*d*) water logging ?
14. Give a brief account of non-renewable energy resources.

**15.** What are solar cells ? Draw a diagram and enumerate its applications.
**16.** Discuss the merits and demerits of wind energy.
**17.** Comment upon the types of energy harnessed from oceans.
**18.** What is biogas ? Discuss the structure and function of biogas plants.
**19.** What is nuclear energy ? Discuss its two types.
**20.** What its soil erosion ? How can it be checked ?
**21.** How can you as an individual conserve different natural resources ?

Unit

# 3 Ecosystems

## ■ CONCEPT OF ECOSYSTEM

Various kinds of life supporting systems like the forests, grasslands, oceans, lakes, rivers, mountains, deserts and estuaries show wide variations in their structural composition and functions. However, they all are alike in the fact that they consist of living entities interacting with their surroundings exchanging matter and energy. How do these different units like a hot desert, a dense evergreen forest, the Antarctic Sea or a shallow pond differ in the type of their flora and fauna, how do they derive their energy and nutrients to live together, how do they influence each other and regulate their stability are the questions that are answered by Ecology.

The term Ecology was coined by Earnst Haeckel in 1869. It is derived from the Greek words *Oikos*- home + *logos*- study. So **ecology deals with the study of organisms in their natural home interacting with their surroundings.** The surroundings or environment consists of other living organisms (biotic) and physical (abiotic) components. Modern ecologists believe that an adequate definition of ecology must specify some unit of study and one such basic unit described by Tansley (1935) was ecosystem. **An ecosystem is a group of biotic communities of species interacting with one another and with their non-living environment exchanging energy and matter. Now ecology is often defined as "the study of ecosystems"**.

An ecosystem is an integrated unit consisting of interacting plants, animals and microorganisms whose survival depends upon the maintenance and regulation of their biotic and abiotic structures and functions. The ecosystem is thus, a unit or a system which is composed of a number of subunits, that are all directly or indirectly linked with each other. They may be freely exchanging energy and matter from outside—an *open ecosystem* or may be isolated from outside—a *closed ecosystem*.

## ■ ECOSYSTEM CHARACTERISTICS

Ecosystems show large variations in their size, structure, composition etc. However, all the ecosystems are characterized by certain basic structural and functional features which are common.

## ■ STRUCTURAL FEATURES

Composition and organization of biological communities and abiotic components constitute the structure of an ecosystem.

### I. Biotic Structure

The plants, animals and microorganisms present in an ecosystem form the biotic component. These organisms have different nutritional behaviour and status in the ecosystems and are accordingly known as *Producers* or *Consumers,* based on how do they get their food.

(*a*) **Producers:** They are mainly the green plants, which can synthesize their food themselves by making use of carbondioxide present in the air and water in the presence of sunlight by involving chlorophyll, the green pigment present in the leaves, through the process of **photosynthesis**. They are also known as **photo autotrophs** (auto=self; troph=food, photo=light).

There are some microorganisms also which can produce organic matter to some extent through oxidation of certain chemicals in the absence of sunlight. They are known as **chemosynthetic** organisms or **chemo-autotrophs**. For instance in the ocean depths, where there is no sunlight, chemoautotrophic sulphur bacteria make use of the heat generated by the decay of radioactive elements present in the earth's core and released in ocean's depths. They use this heat to convert dissolved hydrogen sulphide ($H_2S$) and carbon dioxide ($CO_2$) into organic compounds.

(*b*) **Consumers:** All organisms which get their organic food by feeding upon other organisms are called consumers, which are of the following types:

(*i*) ***Herbivores*** (plant eaters): They feed directly on producers and hence also known as *primary consumers*. e.g. rabbit, insect, man.

(*ii*) ***Carnivores*** (meat eaters): They feed on other consumers. If they feed on herbivores they are called *secondary consumers* (e.g. frog) and if they feed on other carnivores (snake, big fish etc.) they are known as *tertiary carnivores/consumers*.

(*iii*) ***Omnivores***: They feed on both plants and animals. e.g. humans, rat, fox, many birds.

(*iv*) ***Detritivores (Detritus feeders or Saprotrophs):*** They feed on the parts of dead organisms, wastes of living organisms, their cast-offs and partially decomposed matter e.g. beetles, termites, ants, crabs, earthworms etc.

(*c*) **Decomposers:** They derive their nutrition by breaking down the complex organic molecules to simpler organic compounds and ultimately into inorganic nutrients. Various bacteria and fungi are decomposers.

In all the ecosystems, this biotic structure prevails. However, in some, it is the primary producers which predominate (e.g. in forests, agroecosystems) while in others the decomposers predominate (e.g. deep ocean).

### II. Abiotic Structure

The physical and chemical components of an ecosystem constitute its abiotic structure. It includes climatic factors, edaphic (soil) factors, geographical factors, energy, nutrients and toxic substances.

(*a*) ***Physical factors*:** The sunlight and shade, intensity of solar flux, duration of sun hours, average temperature, maximum-minimum temperature, annual rainfall, wind, latitude and altitude, soil type, water availability, water currents etc. are some of the important physical features which have a strong influence on the ecosystem.

We can clearly see the striking differences in solar flux, temperature and precipitation (rainfall, snow etc.) pattern in a desert ecosystem, in a tropical rainforest and in tundra ecosystem.

(*b*) ***Chemical factors***: Availability of major essential nutrients like carbon, nitrogen, phosphorus, potassium, hydrogen, oxygen and sulphur, level of toxic substances, salts causing salinity and various organic substances present in the soil or water largely influence the functioning of the ecosystem.

All the biotic components of an ecosystem are influenced by the abiotic components and vice versa, and they are linked together through energy flow and matter cycling as shown diagrammatically in Fig. 3.1.

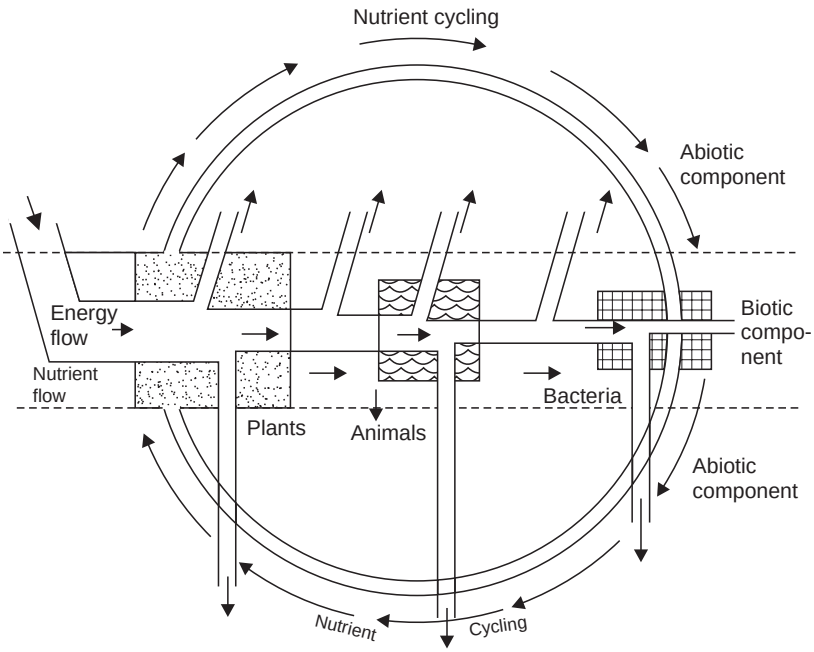



Fig. 3.1. Nutrient cycling and energy flow mediated through food-chain. The flow of energy is unidirectional while the nutrients move in a cyclic manner from the abiotic to biotic (food chain) to abiotic and so on.

## ■ FUNCTIONAL ATTRIBUTES

Every ecosystem performs under natural conditions in a systematic way. It receives energy from the sun and passes it on through various biotic components and in fact, all life depends upon this flow of energy. Besides energy, various nutrients and water are also required for life processes which are exchanged by the biotic components within themselves and with their abiotic components within or outside the ecosystem. The biotic components also regulate themselves in a very systematic manner and show mechanisms to encounter some degree of environmental stress. The major functional attributes of an ecosystems are as follows:

(*i*) Food chain, food webs and trophic structure
(*ii*) Energy flow
(*iii*) Cycling of nutrients (Biogeochemical cycles)
(*iv*) Primary and Secondary production
(*v*) Ecosystem development and regulation

## ■ TROPHIC STRUCTURE

The structure and functions of ecosystems are very closely related and influence each other so intimately that they need to be studied together. The flow of energy is mediated through a series of feeding relationships in a definite sequence or pattern which is known as **food chain**. Nutrients too move along the food chain. The producers and consumers are arranged in the ecosystem in a definite manner and their interaction along with population size are expressed together as **trophic structure**. Each food level is known as **trophic level** and the amount of living matter at each trophic level at a given time is known as **standing crop** or **standing biomass**.

Before we study about energy flow or nutrient cycling, we must learn about the food-chains, that provide the path through which the flow of energy and matter take place in ecosystem.

## ■ FOOD CHAINS

**The sequence of eating and being eaten in an ecosystem is known as food chain.** All organisms, living or dead, are potential food for some other organism and thus, there is essentially no waste in the functioning of a natural ecosystem. A caterpillar eats a plant leaf, a sparrow eats the caterpillar, a cat or a hawk eats the sparrow and when they all die, they are all consumed by microorganisms like bacteria or fungi (decomposers) which break down the organic matter and convert it into simple inorganic substances that can again be used by the plants-the primary producers.

Some common examples of simple food chains are:

- Grass → grasshopper → Frog → Snake → Hawk (Grassland ecosystem)
- Phytoplanktons → water fleas → small fish → Tuna (Pond ecosystem)
- Lichens → reindeer → Man (Arctic tundra)

Each organism in the ecosystem is assigned a feeding level or trophic level depending on its nutritional status. Thus, in the grassland food chain, grasshopper occupies the Ist trophic level, frog the IInd and snake and hawk occupy the IIIrd and the IVth trophic levels, respectively. The decomposers consume the dead matter of all these trophic levels. In nature, we come across two major types of food chains:

**I. Grazing food chain:** It starts with green plants (primary producers) and culminates in carnivores. All the examples cited above show this type of food chain. Another example could be

Grass → Rabbit → Fox

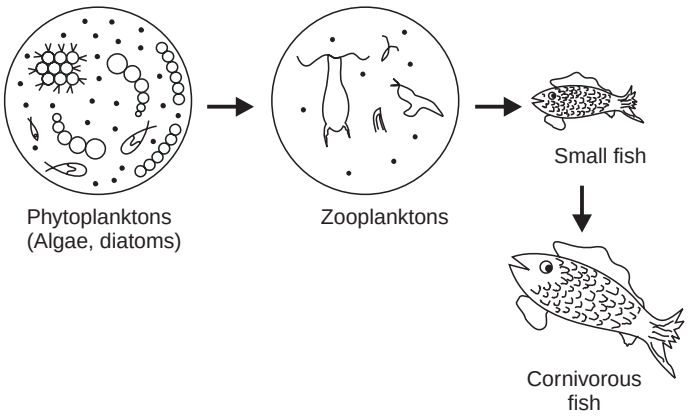



Fig. 3.2. A grazing food chain in a pond ecosystem.

**II. Detritus food chain:** It starts with dead organic matter which the detritivores and decomposers consume. Partially decomposed dead organic matter and even the decomposers are consumed by detritivores and their predators. An example of the detritus food chain is seen in a Mangrove (estuary).

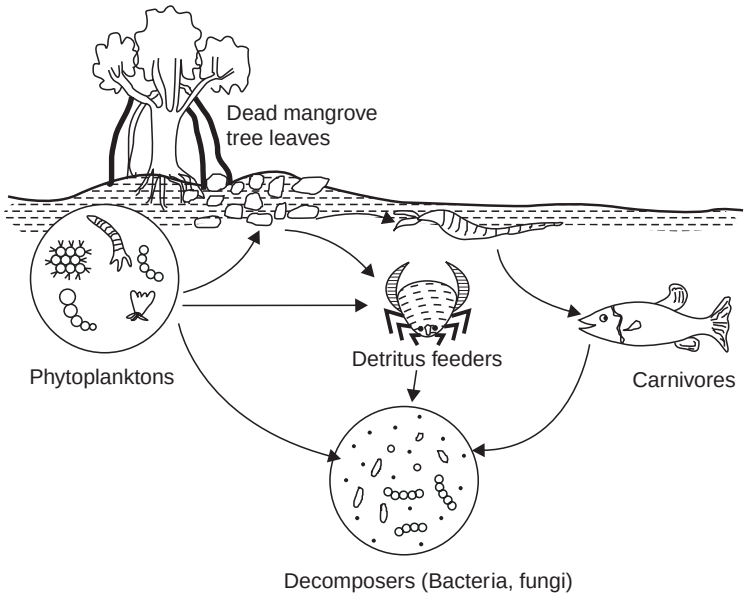



Fig. 3.3. A detritus food chain in an estuary based on dead leaves of mangrove trees.

Here, a large quantity of leaf material falls in the form of litter into the water. The leaf fragments are eaten by **saprotrophs.** (Saprotrophs are those organisms which feed on dead organic matter). These fallen leaves are colonized by small algae, which are also consumed by the saprotrophs or detritivores consisting of crabs, mollusks, shrimps, insect larvae, nematodes and fishes. The detritivores are eaten by small carnivorous fishes, which is turn are eaten by large carnivorous fishes.

Leaf litter → algae → crabs → small carnivorous fish → large carnivorous fish (Mangrove ecosystem)

Dead organic matter → fungi → bacteria (Forest ecosystem)

Thus the grazing food chain derives its energy basically from plant energy while in the detritus food chain it is obtained primarily from plant biomass, secondarily from microbial biomass and tertiarily from carnivores. Both the food chains occur together in natural ecosystems, but grazing food chain usually predominates.

## ■ FOOD WEB

Food chains in ecosystems are rarely found to operate as isolated linear sequences. Rather, they are found to be interconnected and usually form a complex network with several linkages and are known as food webs. Thus, **food web is a network of food chains where different types of organisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level.**

Fig. 3.4 illustrates an example of a food-web in the unique Antarctic Ecosystem. This is representing the total ecosystem including the Antarctic sea and the continental land. The land does not show any higher life forms of plants. The only species are that of some algae, lichens and mosses. The animals include penguins and snow petrel which depend upon the aquatic chain for their food energy.

In a tropical region, on the other hand, the ecosystems are much more complex. They have a rich species diversity and therefore, the food webs are much more complex.

Why nature has evolved food webs in ecosystems instead of simple linear food chains? This is because food webs give greater stability to the ecosystem. In a linear food chain, if one species becomes extinct or one species suffers then the species in the subsequent trophic levels are also affected. In a food web, on the other hand, there are a number of options available at each trophic level. So if one species is affected, it does not affect other trophic levels so seriously.

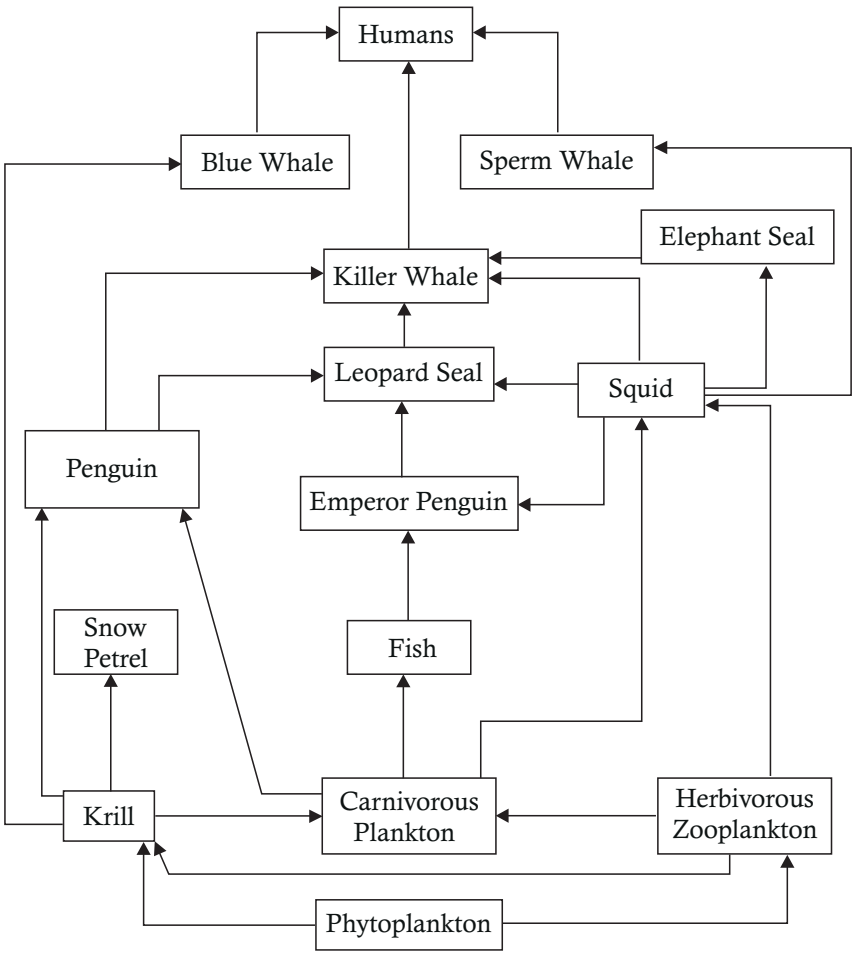



Fig. 3.4. A simplified food web in Antarctic ecosystem.

Just consider the simple food chains of arctic tundra ecosystem:

Cladonia → Reindeer → Man

Grass → Caribou → Wolf

If due to some stress, the population of reindeer or Caribou falls, it will leave little option for man or wolf to eat from the ecosystem. Had there been more biodiversity, it would have led to complex food web giving the ecosystem more stability.

**Significance of food chains and food webs**

- Food chains and food webs play a very significant role in the ecosystem because the two most important functions of ***energy flow and nutrient cycling take place through them.***

- The food chains also help in maintaining and regulating the population size of different animals and thus, help maintain the ***ecological balance*.**
- Food chains show a unique property of **biological magnification** of some chemicals. There are several pesticides, heavy metals and other chemicals which are non-biodegradable in nature. Such chemicals are not decomposed by microorganisms and they keep on passing from one trophic level to another. And, at each successive trophic level, they keep on increasing in concentration. This phenomenon is known as biomagnification or biological magnification.

**CASE STUDY**

A **build-up of DDT concentration :** A striking case of biomagnification of DDT (a broad range insecticide) was observed when some birds like Osprey were found to suffer a sharp decline in their population. The young ones of these birds were found to hatch out in premature condition leading to their death. This was later found to be due to bio-magnification of DDT through the food chain. DDT sprayed for pest control was in very low concentration, but its concentration increased along the food chain through phytoplanktons to zooplanktons and then to fish which was eaten by the birds. The concentration of DDT was magnified several thousand times in the birds which caused thinning of shells in the birds' eggs, causing death of the young ones.

It becomes very clear from the above instance that the animals occupying the higher trophic levels are at a greater risk of biomagnification of toxic chemicals. Human beings consuming milk, eggs and meat are at a higher trophic level. So, we have to stop indiscriminate use of pesticides and heavy metals if we wish to save ourselves from their biologically magnified toxic levels.

## ■ ECOLOGICAL PYRAMIDS

**Graphic representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is knows as an ecological pyramid.** Ecological pyramids are of three types:

**Pyramid of numbers:** It represents the number of individual organisms at each trophic level. We may have *upright* or *inverted* pyramid

of numbers, depending upon the type of ecosystem and food chain as shown in Fig. 3.5. A grassland ecosystem (Fig. 3.5*a*) and a pond ecosystem show an upright pyramid of numbers. The producers in the grasslands are grasses and that in a pond are phytoplanktons (algae etc.), which are small in size and very large in number. So the producers form a broad base. The herbivores in a grassland are insects while tertiary carnivores are hawks or other birds which are gradually less and less in number and hence the pyramid apex becomes gradually narrower forming an upright pyramid. Similar is the case with the herbivores, carnivores and top carnivores in pond which decrease in number at higher trophic levels.

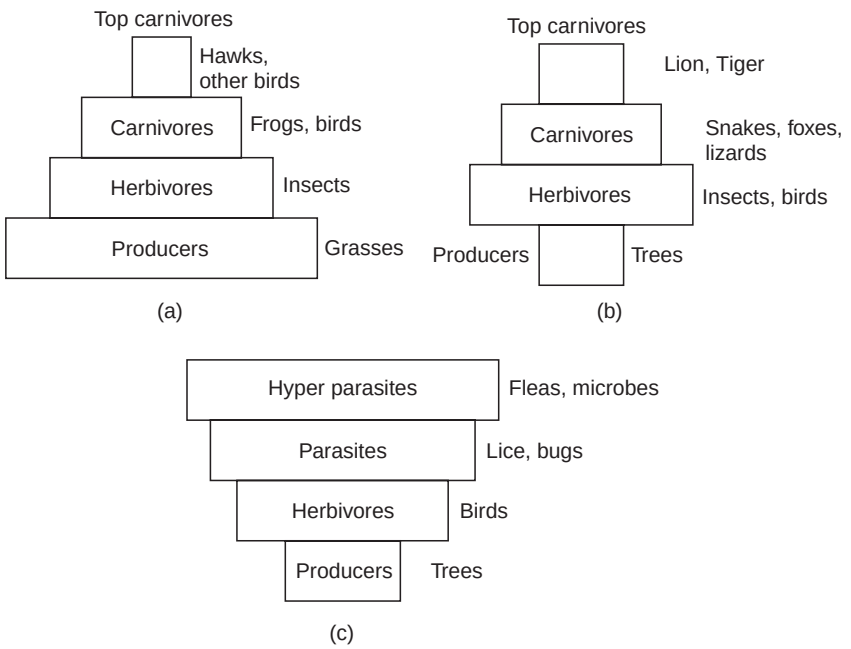



Fig. 3.5. Pyramid of numbers (*a*) grassland (*b*) forest (*c*) Parasitic food chain.

In a forest ecosystem, big trees are the producers, which are less in number and hence form a narrow base. A larger number of herbivores including birds, insects and several species of animals feed upon the trees (on leaves, fruits, flowers, bark etc.) and form a much broader middle level. The secondary consumers like fox, snakes, lizards etc. are less in number than herbivores while top carnivores like lion, tiger etc. are still smaller in number. So the pyramid is narrow on both sides and broader in the middle (Fig. 3.5 *b*).

Parasitic food chain shows an inverted pyramid of number. The producers like a few big trees harbour fruit eating birds acting like

herbivores which are larger in number. A much higher number of lice, bugs etc. grow as parasites on these birds while a still greater number of hyperparasites like bugs, fleas and microbes feed upon them, thus making an inverted pyramid (Fig. 3.5 *c*).

**Pyramid of biomass:** It is based upon the total biomass (dry matter) at each trophic level in a food chain. The pyramid of biomass can also be *upright* or *inverted.* Fig. 3.6 (*a, b*) show pyramids of biomass in a forest and an aquatic ecosystem. The pyramid of biomass in a forest is upright in contrast to its pyramid of numbers. This is because the producers (trees) accumulate a huge biomass while the consumers' total biomass feeding on them declines at higher trophic levels, resulting in broad base and narrowing top.

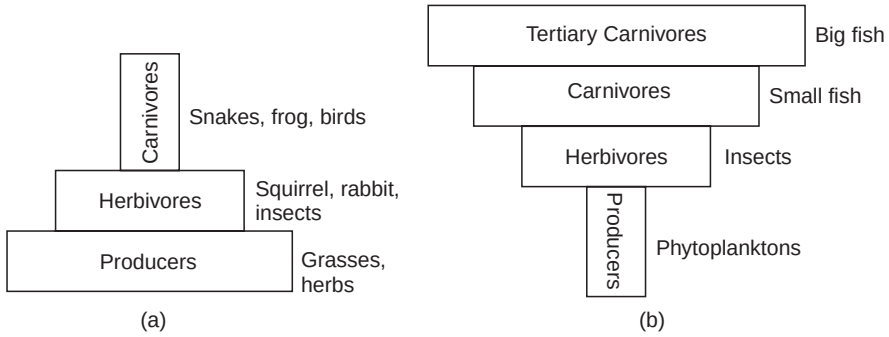



Fig. 3.6. Pyramid of biomass (*a*) Grassland (*b*) Pond.

The pond ecosystem shows an inverted pyramid of biomass (Fig. 3.6 *b*). The total biomass of producers (phytoplanktons) is much less as compared to herbivores (zooplanktons, insects), Carnivores (Small fish) and tertiary carnivores (big fish). Thus the pyramid takes an inverted shape with narrow base and broad apex.

**Pyramid of Energy:** The amount of energy present at each trophic level is considered for this type of pyramid. Pyramid of energy gives the best representation of the trophic relationships and it is always *upright*.

At every successive trophic level, there is a huge loss of energy (about 90%) in the form of heat, respiration etc. Thus, at each next higher level only 10% of the energy passes on. Hence, there is a sharp decline in energy level of each successive trophic level as we move from producers to top carnivores. Therefore, the pyramid of energy is always upright as shown in Fig. 3.7.

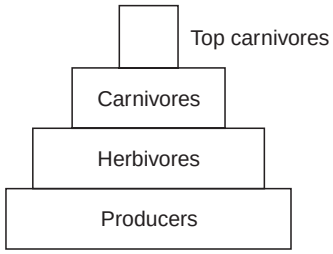



Fig. 3.7. Pyramid of energy.

## ■ ENERGY FLOW IN AN ECOSYSTEM

Flow of energy in an ecosystem takes place through the food chain and it is this energy flow which keeps the ecosystem going. The most important feature of this energy flow is that it is **unidirectional** or **one-way flow.** Unlike the nutrients (like carbon, nitrogen, phosphorus etc.) which move in a cyclic manner and are reused by the producers after flowing through the food chain, energy is not reused in the food chain. Also, the flow of energy follows the two laws of Thermodynamics:

**Ist law of Thermodynamics** states that energy can neither be created nor be destroyed but it can be transformed from one form to another. The solar energy captured by the green plants (producers) gets converted into biochemical energy of plants and later into that of consumers.

**IInd law of Thermodynamics** states that energy dissipates as it is used or in other words, its gets converted from a more concentrated to dispersed form. As energy flows through the food chain, there occurs dissipation of energy at every trophic level. The loss of energy takes place through respiration, loss of energy in locomotion, running, hunting and other activities. At every level there is about 90% loss of energy and the energy transferred from one trophic level to the other is only about 10%.

**Energy flow models:** The flow of energy through various trophic levels in an ecosystem can be explained with the help of various energy flow models.

(*a*) **Universal energy flow model:** Energy flow through an ecosystem was explained by E.P. Odum as the universal energy flow model (Fig. 3.8). As the flow of energy takes place, there is a gradual loss of energy at every level, thereby resulting in less energy available at next trophic level as indicated by narrower pipes (energy flow) and smaller boxes (stored energy in biomass). The loss of energy is mainly the energy not utilized (NU). This is the energy lost in locomotion,

excretion etc. or it is the energy lost in respiration (R) which is for maintenance. The rest of the energy is used for production (P).

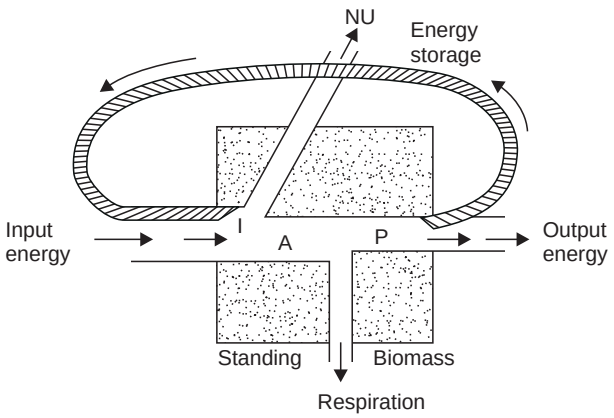



Fig. 3.8. Universal energy flow model applicable to all living components (I = Energy input; A : assimilated energy ; P = Production ; NU = Energy not used.

(*b*) **Single channel energy flow model:** The flow of energy takes place in a unidirectional manner through a single channel of green plants or producers to herbivores and carnivores. Fig. 3.9 depicts such a model and illustrated the gradual decline in energy level due to loss of energy at each successive trophic level in a grazing food chain.

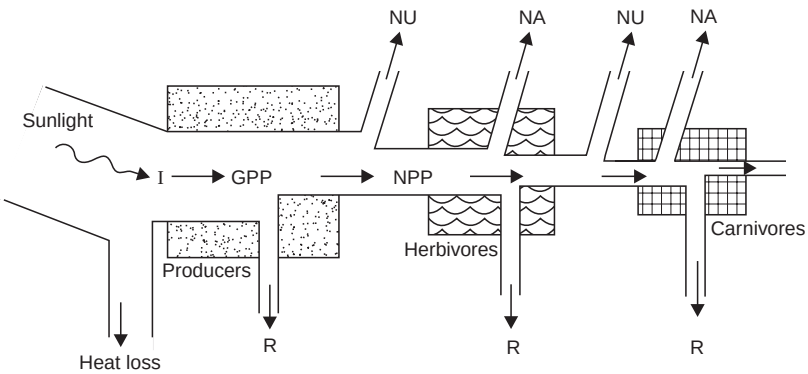



Fig. 3.9. One-way energy flow model showing unidirectional flow through primary producers, herbivores and carnivores. At each successive trophic level there is huge loss of energy (I = Solar energy input ; GPP = Gross primary production ; NPP = Net primary production ; NU = Energy not used ; NA = Energy not assimilated e.g. excretion ; R = Respiratory loss).

(*c*) **Double channel or Y-shaped energy flow model:** In nature, both grazing food chain and detritus food chain operate in the same ecosystem. However, sometimes it is the grazing food chain which predominates. It happens in marine ecosystem where primary production in the open sea is limited and a major portion of it is eaten by herbivorous marine animals. Therefore, very little primary production is left to be passed on to the dead or detritus compartment. On the other hand, in a forest ecosystem the huge quantity of biomass produced cannot be all consumed by herbivores. Rather, a large proportion of the live biomass enters into detritus (dead) compartment in the form of litter. Hence the detritus food chain is more important there.

The two channel or Y-shaped model of energy flow shows the passage of energy through these two chains, which are separated in time and space (Fig 3.10).

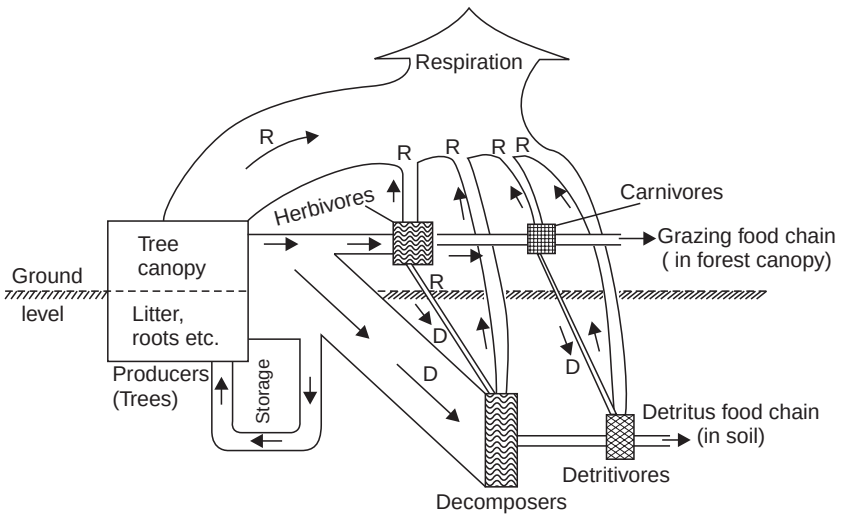



Fig. 3.10. Y-shaped or 2-channel energy flow model showing energy flow through the grazing food chain and the detritus food chain (R = Respiration, D = Detritus or dead matter).

## ■ NUTRIENT CYCLING

Besides energy flow, the other important functional attribute of an ecosystem is nutrient cycling. Nutrients like carbon, nitrogen, sulphur, oxygen, hydrogen, phosphorus etc. move in circular paths through biotic and abiotic components and are therefore known as **biogeochemical cycles.** Water also moves in a cycle, known as hydrological cycle. The nutrients too move through the food chain and ultimately reach the

detritus compartment (containing dead organic matter) where various micro-organisms carry out decomposition. Various organically bound nutrients of dead plants and animals are converted into inorganic substances by microbial decomposition that are readily used up by plants (primary producers) and the cycle starts afresh.

### Nitrogen cycle

Cycling of one such important nutrient nitrogen is shown in Fig. 3.11. Nitrogen is present in the atmosphere as $N_2$ in large amount (78%) and it is fixed either by the physical process of lightening or biologically by some bacteria and/or cyanobacteria (blue green algae). The nitrogen is taken up by plants and used in metabolism for biosynthesis of amino acids, proteins, vitamins etc. and passes through the food chain. After death of the plants and animals, the organic nitrogen in dead tissues is decomposed by several groups of ammonifying and nitrifying bacteria which convert them into ammonia, nitrites and nitrates, which are again used by plants. Some bacteria convert nitrates, into molecular nitrogen or $N_2$ which is released back into the atmosphere and the cycle goes on.

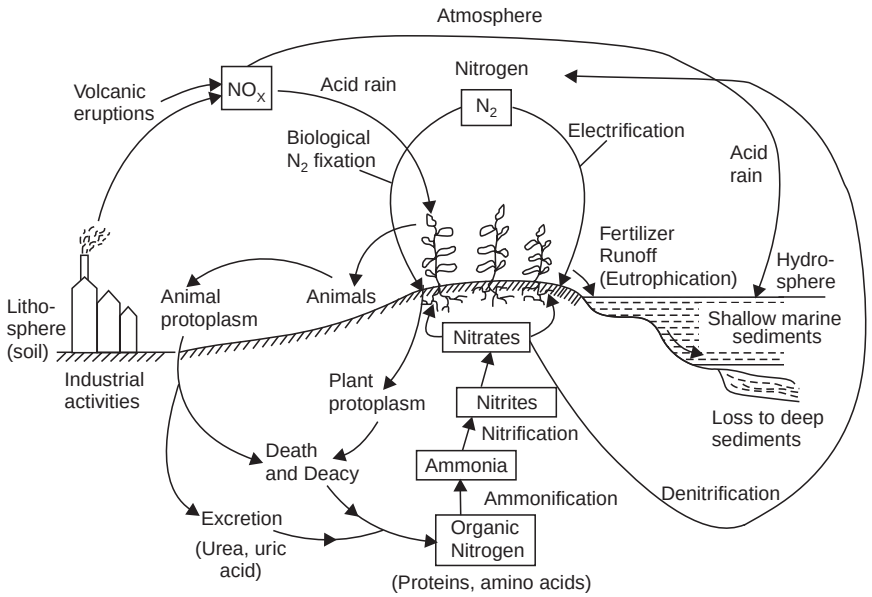



Fig. 3.11. Nitrogen cycle—a gaseous cycle with major reserve as $N_2$ (78%) in the atmosphere. Circulation of N- between living components and soil/atmosphere is mediated by a group of micro-organisms which convert one form of N into another.

## Carbon Cycle

Sometimes human interferences disturb the normal cycling of such nutrients and create imbalances. For example, nature has a very balanced carbon cycle (Fig. 3.12). Carbon, in the form of carbon dioxide is taken up by green plants as a raw material for photosynthesis, through which a variety of carbohydrates and other organic substances are produced. Through the food chain it moves and ultimately organic carbon present in the dead matter is returned to the atmosphere as carbon dioxide by microorganisms. Respiration by all organisms produces carbon dioxide, while the latter is used up by plants.

In the recent years carbon dioxide levels have increased in the atmosphere due to burning of fossil fuels etc. which has caused an imbalance in the natural cycle and the world today is facing the serious problem of global warming due to enhanced carbon dioxide emissions.

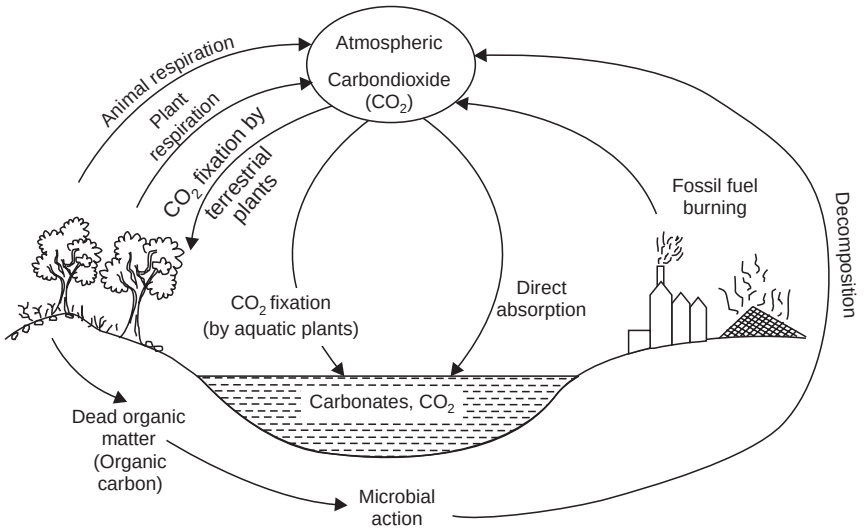



Fig. 3.12. Carbon cycle.

## Phosphorus cycle

Phosphorous cycle is another important nutrient cycle-which is shown in Fig. 3.13. The reservoir of phosphorus lies in the rocks, fossils etc. which is excavated by man for using it as a fertilizer. Farmers use the phosphate fertilizers indiscriminately and as a result excess phosphates are lost as run-off, which causes the problem of eutrophication or overnourishment of lakes leading to algal blooms as already discussed

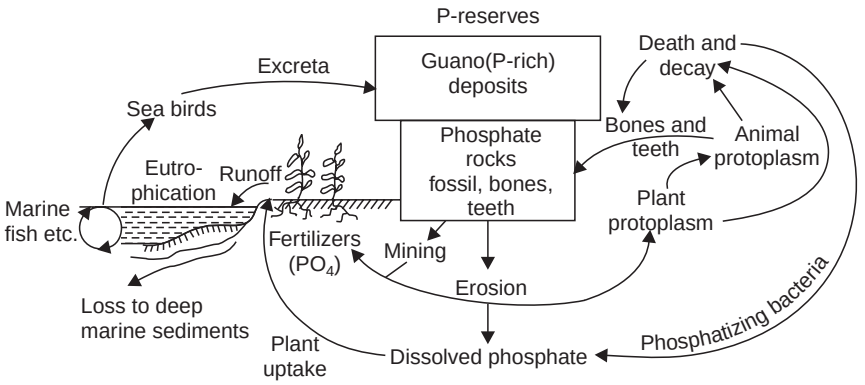



Fig. 3.13. Phosphorus cycle—a sedimentary cycle with major reserves of phosphorus in the sediments.

in unit 2. A good proportion of phosphates moving with surface run-off reaches the oceans and are lost into the deep sediments. Our limited supply of phosphorus lying in the phosphate rocks of this earth are thus over-exploited by man and a large part is taken out of the normal cycle due to loss into oceans. So human beings are making the phosphorous cycle acyclic. Sea birds, on the other hand, are playing an important role in phosphorus cycling. They eat sea-fishes which are phosphorus rich and the droppings or excreta of the birds return the phosphorus on the land. The Guano deposits on the coasts of Peru are very rich sources of phosphorus.

## ■ PRIMARY PRODUCTION

**Primary productivity of an ecosystem is defined as the rate at which radiant energy is converted into organic substances by photosynthesis or chemo-synthesis by the primary producers.**

When organic matter is produced by the primary producers (mainly green plants and some microorganisms), some of it is oxidized or burnt inside their body and converted into carbon-dioxide which is released during respiration and is accompanied by loss of energy. Respiratory loss of energy is a must, because it is required for the maintenance of the organism. Now, the producers are left with a little less organic matter than what was actually produced by them. This is known as the **net primary production** (NPP) and the respiratory loss (R) added to it gives the **gross primary production** (GPP).

Thus, $NPP = GPP - R$.

Primary production of an ecosystem depends upon the solar radiations, availability of water and nutrients and upon the type of the plants and their chlorophyll content. Table 3.1 shows the average gross primary productivity of some major ecosystems.

**Table 3.1. Annual average of gross primary production of some major ecosystems**

| Ecosystem | Gross Primary Productivity (K Cal/$m^2$/yr) |
|---|---|
| Deserts and Tundra | 200 |
| Open Oceans | 1,000 |
| Grasslands | 2,500 |
| Moist Temperate Forests | 8,000 |
| Agro-ecosystems | 12,000 |
| Wet Tropical Forests | 20,000 |
| Estuaries | 20,000 |

Productivity of tropical forests and estuaries are the highest. This is because tropical forests have abundant rainfall, warm temperature congenial for growth, abundant sunlight and a rich diversity of species. Estuaries get natural energy subsidies in the form of wave currents that bring along with them nutrients required for production.

Deserts on the other hand, have limitations of adequate water supply while Tundra have very low temperature as limiting factor and hence show low primary production.

Agro-ecosystems get lots of energy subsidies in the form of irrigation water, good quality seeds, fertilizers and pesticides and show a high productivity of 12,000 K Cal/$m^2$/yr. Still, it is noteworthy that their productivity is less than that of tropical forests which are not receiving any artificial energy subsidies. Nature itself has designed its species composition, structure, energy capture and flow, and a closed nutrient cycling system that ensures a high primary production of 20,000 K Cal/$m^2$/yr. Also, the qualitative variety of the primary production is enormous in the tropical forests. This makes it all the more important to conserve our tropical forests.

### Secondary Production

The food synthesized by green plants through photosynthesis is the primary production which is eaten by herbivores. The plant energy is used up for producing organic matter of the herbivores which, in turn, is used up by the carnivores. The amount of organic matter stored by the herbivores or carnivores (in excess of respiratory loss) is known as secondary production. **The energy stored at consumer level for use by the next trophic level is thus defined as secondary production.**

## ■ ECOSYSTEM REGULATION

All ecosystems regulate themselves and maintain themselves under a set of environmental conditions. Any environmental stress tries to disturb the normal ecosystem functions. However, the ecosystem, by itself, tries to resist the change and maintain itself in equilibrium with the environment due to a property known as **homeostasis. Homeostasis is the inherent property of all living systems to resist change.** However, the system can show this tolerance or resistance only within a maximum and a minimum range, which is its range of tolerance known as *homeostatic plateau*. Within this range, if any stress tries to cause a deviation, then the system has its own mechanisms to counteract these deviations which are known as **negative feedback mechanisms. So negative feedback mechanisms are deviation counteracting mechanisms which try to bring the system back to its ideal conditions.** But, if the stress is too high and beyond the range of homeostatic plateau, then another type of mechanisms known as **positive feedback mechanisms** start operating. These are the deviation accelerating mechanisms. **So the positive feedback mechanisms add to the stress conditions and tend to take the system away from the optimal conditions.** Fig. 3.14 depicts the ecosystem regulation mechanisms.

Human beings should try to keep the ecosystems within the homeostatic plateau. They should not contribute to positive feedbacks otherwise the ecosystems will collapse.

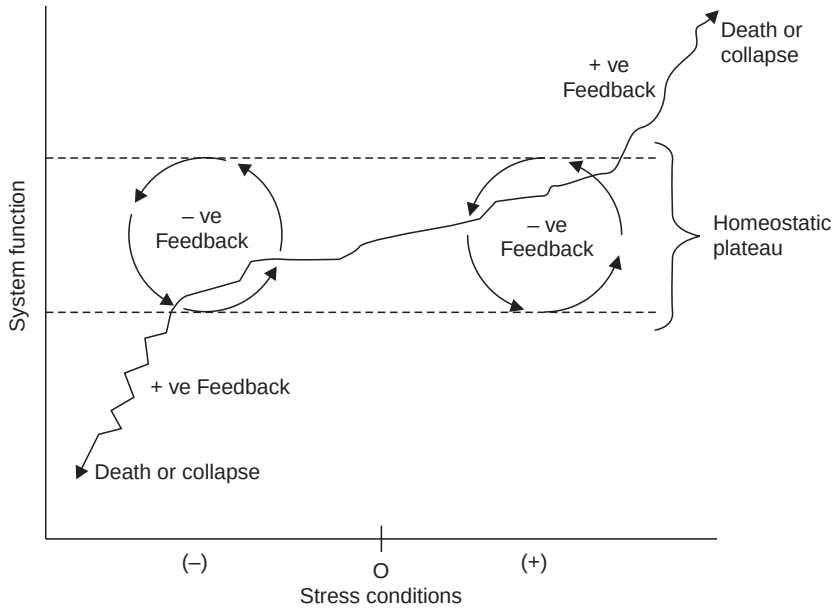



Fig. 3.14. Ecosystem regulation by homeostasis. On application of a stress, the negative feedback mechanisms start operating, trying to counter the stress to regulate the system. But beyond the homeostatic plateau, positive feedback starts which further accelerate the stress effects causing death or collapse of the organism/system.

## ■ ECOLOGICAL SUCCESSION

An ecosystem is not static in nature. It is dynamic and changes its structure as well as function with time and quite interestingly, these changes are very orderly and can be predicted. It is observed that one type of a community is totally replaced by another type of community over a period of time and simultaneously several changes also occur. This process is known as ecological succession.

**Ecological succession is defined as an orderly process of changes in the community structure and function with time mediated through modifications in the physical environment and ultimately culminating in a stabilized ecosystem known as climax.** The whole sequence of communities which are transitory are known as *Seral stages* or *seres* whereas the community establishing first of all in the area is called a *pioneer* community.

Ecological successions starting on different types of areas or substrata are named differently as follows:

(*i*) **Hydrarch or Hydrosere:** Starting in watery area like pond, swamp, bog

(*ii*) **Mesarch:** starting in an area of adequate moisture.

(*iii*) **Xerarch or Xerosere:** Starting in a dry area with little moisture. They can be of the following types:

| | | |
|---|---|---|
| Lithosere | : | starting on a bare rock |
| Psammosere | : | starting on sand |
| Halosere | : | starting on saline soil |

## Process of Succession

The process of succession takes place in a systematic order of sequential steps as follows:

(*i*) **Nudation:** It is the development of a bare area without any life form. The bare area may be caused due to landslides, volcanic eruption etc. (topographic factor), or due to drought, glaciers, frost etc. (Climatic factor), or due to overgrazing, disease outbreak, agricultural/ industrial activities (biotic factors).

(*ii*) **Invasion:** It is the successful establishment of one or more species on a bare area through **dispersal** or **migration**, followed by **ecesis** or **establishment.** Dispersal of the seeds, spores etc. is brought about by wind, water, insects or birds. Then the seeds germinate and grow on the land. As growth and reproduction start, these **pioneer species** increase in number and form groups or **aggregations.**

(*iii*) **Competition and coaction:** As the number of individuals grows there is competition, both inter-specific (between different species) and intra-specific (within the same species), for space, water and nutrition. They influence each other in a number of ways, known as **coaction.**

(*iv*) **Reaction:** The living organisms grow, use water and nutrients from the substratum, and in turn, they have a strong influence on the environment which is modified to a large extent and this is known as **reaction.** The modifications are very often such that they become unsuitable for the existing species and favour some new species, which replace them. Thus, reaction leads to several **seral communities.**

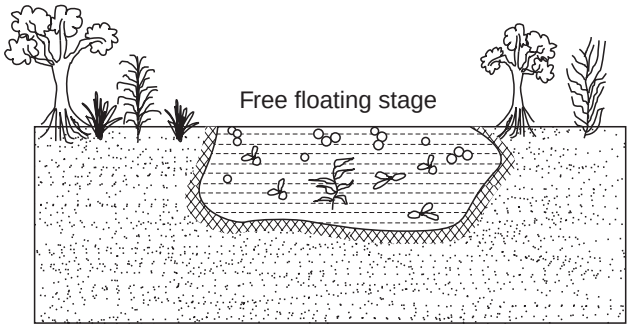
(*v*) **Stabilization:** The succession ultimately culminates in a more or less stable community called **climax** which is in equilibrium with the environment.

The climax community is characterized by maximum biomass and symbiotic (mutually beneficial) linkages between organisms and are maintained quite efficiently per unit of available energy.

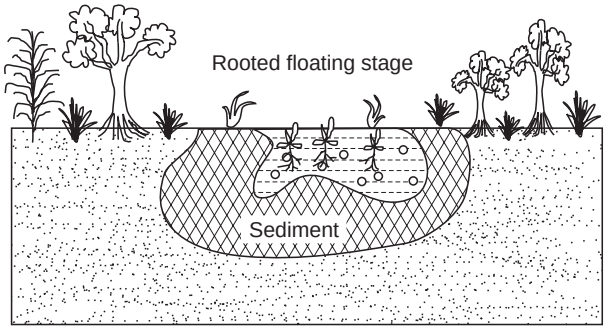
Let us consider very briefly two types of succession.

**A. Hydrosere (Hydrarch):** This type of succession starts in a water body like pond. A number of intermediate stages come and ultimately it culminates in a climax community which is a forest.

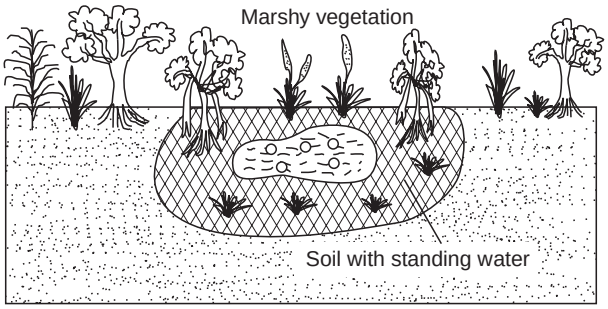
The pioneer community consists of phytoplanktons, which are free floating algae, diatoms etc. Gradually these are replaced by rooted-submerged plants followed by rooted-floating plants. Growth of these plants keep on adding organic matter to the substratum by death and



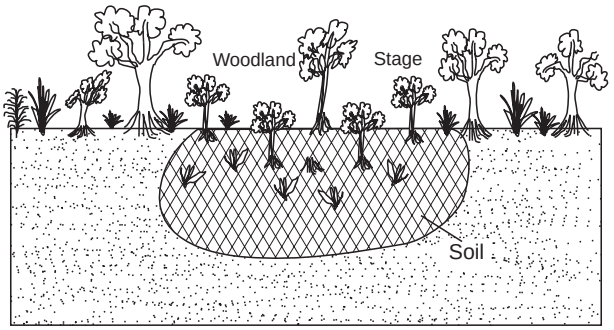

(*a*) Open water body (lake), sediment brought in by river.




(*b*) Sediment accumulation continues, organic debris from plants too add to soil formation and shrinking of water body occurs.




(*c*) A mat of vegetation covers the water which is mostly a marshy habitat now, with a small part as aquatic system.




(*d*) Eventually the former lake is covered by climax woodland community, representating a terrestrial ecosystem.

Fig. 3.15. Ecological succession: A hydrach—from lake to woodland community.

decay and thus a layer of soil builds up and shallowing of water takes place. Then Reed swamp (marshy) stage follows in which the plants are partly in water and partly on land. This is followed by a sedge-meadow stage of grasses then by a woodland consisting of shrubs and trees and finally by a forest acting as climax. (Fig. 3.15)

**B. Xerosere (Xerarch):** This type of succession originates on a bare rock, which lacks water and organic matter. Interestingly, here also the climax community is a forest, although the intermediate stages are very different.

The pioneer community here consists of crustose and foliose lichens. These lichens produce some weak acids and help in disintegrating the rock, a process known as *weathering*. Their growth helps in building up gradually some organic matter, humus and soil. Then comes the community of mosses, followed by herbs, shrubs and finally the forest trees. Throughout this gradual process there is a slow build up of organic matter and water in the substratum.

Thus, succession tends to move towards mesic conditions (moderate condition), irrespective of the fact, whether it started from a dry (Xeric) condition or a moist (hydric) condition and it culminates in a stable climax community, which is usually a forest.

## MAJOR ECOSYSTEM TYPES

Let us consider types, characteristic features, structure and functions of some major ecosystems.

## ■ FOREST ECOSYSTEM

These are the ecosystems having a predominance of trees that are interspersed with a large number of species of herbs, shrubs, climbers, lichens, algae and a wide variety of wild animals and birds. As discussed above forests are found in undisturbed areas receiving moderate to high rainfall and usually occur as stable climax communities.

Depending upon the prevailing climatic conditions forests can be of various types:

(*a*) **Tropical Rain Forests:** They are evergreen broadleaf forests found near the equator. They are characterized by high temperature, high humidity and high rainfall, all of which favour the growth of trees. All through the year the climate remains more or less uniform. They are the richest in biodiversity. Different forms of life occupy specialized areas (niches) within different layers and spaces of the ecosystem depending upon their needs for food, sunlight, water, nutrient etc.

We come across different types and layers of plants and animals in the tropical rain forests. e.g. the **emergent layer** is the topmost layer of the tallest broad-leaf evergreen trees, below which lies the **canopy** where top branches of shorter trees form an umbrella like cover. Below this is present the **understory** of still smaller trees. On the tree trunks some woody climbers are found to grow which are known as **Lianas**. There are some other plants like **Orchids** which are **epiphytes** i.e. they are attached to the trunks or branches of big trees and they take up water and nutrients falling from above. The orchids have special type of leaves to capture and hold the water. *Some large epiphytes can hold as much as 4 litres of water, equivalent to a small bucket*! Thus, these epiphytes almost act like mini-ponds suspended up in the air, in the forest crown. That is the reason why a large variety of birds, insects and animals like monkeys have made their natural homes (habitats) in these forests (Plate II).

The understorey trees usually receive very dim sunlight. They usually develop dark green leaves with high chlorophyll content so that they can use the diffused sunlight for photosynthesis. The **shrub layer** receives even less sunlight and the **ground layer** commonly known as **forest floor** receives almost no sunlight and is a dark layer. Most of the animals like bats, birds, insects etc. occupy the bright canopy layer while monkeys, toads, snakes, chameleons etc. keep on moving up and down in sunny and darker layers. Termites, fungi, mushrooms etc. grow on the ground layer. Warm temperature and high availability of moisture facilitate rapid breakdown (decomposition) of the dropped leaves, twigs etc. releasing the nutrients rapidly. These nutrients are immediately taken up by the **mycorrhizal** roots of the trees.

Plate II. Tropical rain forest.

Interestingly, the flowers of forest trees are very large, colourful, fragrant and attractive which helps in pollination by insects, birds, bats etc. *Rafflesia arnoldi*, the biggest flower (7 kg weight) is known to smell like rotten meat and attracts flies and beetles which help in its pollination (Plate III).

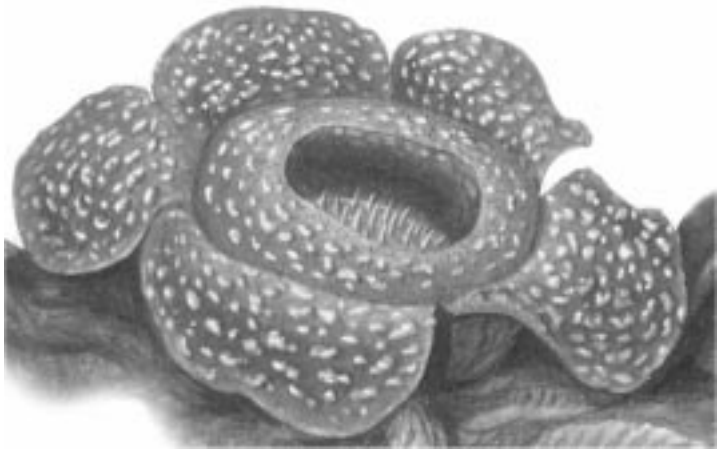


Plate III. Rafflesia—the biggest flower.

The Silent Valley in Kerala is the only tropical rain forest lying in India which is the natural habitat for a wide variety of species.

Being the store-house of biodiversity, the forests provide us with an array of commercial goods like timber, fuel wood, drugs, resins, gums etc. Unfortunately there is cutting down of these forests at an alarming rate. Within the next 30-40 years we are likely to be left with only scattered fragments of such forests, thereby losing the rich biodiversity and the ecological uses of forests, discussed earlier in unit II.

(*b*) **Tropical deciduous forests:** They are found a little away from the equator and are characterized by a warm climate the year round. Rain occurs only during monsoon. A large part of the year remains dry and therefore different types of deciduous trees are found here, which lose their leaves during dry season.

(*c*) **Tropical scrub forests:** They are found in areas where the dry season is even longer. Here there are small deciduous trees and shrubs.

(*d*) **Temperate rain forests:** They are found in temperate areas with adequate rainfall. These are dominated by coniferous trees like pines, firs, redwoods etc. They also consist of some evergreen broad-leaf trees.

(*e*) **Temperate deciduous forests:** They are found in areas with moderate temperatures. There is a marked seasonality with long summers, cold but not too severe winter and abundant rainfall throughout the year. The major trees include broad leaf deciduous trees like oak, hickory, poplar etc.

(*f*) **Evergreen coniferous forests (Boreal Forests):** They are found just south of arctic tundra. Here winters are long, cold and dry. Sunlight is available for a few hours only. In summer the temperature is mild, sun-shines for long hours but the season is quite short. The major trees include pines, spruce, fir, cedar etc. which have tiny, needle-shaped leaves having a waxy coating so that they can withstand severe cold and drought. The soil is found to get frozen during winter when few species can survive. The leaves, also know as needles, fall on the forest floor and cover the nutrient poor soil. These soils are acidic and prevent other plants from growing. Species diversity is rather low in these forests.

## ■ GRASSLAND ECOSYSTEMS

Grasslands are dominated by grass species but sometimes also allow the growth of a few trees and shrubs. Rainfall is average but erratic. Limited grazing helps to improve the net primary production of the grasslands but overgrazing leads to degradation of these grasslands resulting in desertification. Three types of grasslands are found to occur in different climatic regions:

(*a*) **Tropical grasslands:** They occur near the borders of tropical rain forests in regions of high average temperature and low to moderate rainfall. In Africa, these are typically known as **Savannas**, which have tall grasses with scattered shrubs and stunted trees. The Savannas have a wide diversity of animals including zebras, giraffes, gazelle, antelopes etc. During dry season, fires are quite common. Termite mounds are very common here. The termites gather the detritus (dead organic matter) containing a lot of cellulose and build up a mound. On the top of the mound fungi are found to grow which feed upon this dead matter including cellulose and in turn release methane, a greenhouse gas.

Tropical savannas have a highly efficient system of photosynthesis. Most of the carbon assimilated by them in the form of carbohydrates is in the perennating bulbs, rhizomes, runners etc. which are present underground. Deliberate burning of these grasslands can relase huge quantities of carbon dioxide, another green house gas, responsible for global warming.

(*b*) **Temperate grasslands:** They are usually found on flat, gentle sloped hills, winters are very cold but summers are hot and dry. Intense grazing and summer fires do not allow shrubs or trees to grow.

In United States and Canada these grasslands are known as **prairies,** in South America as **Pampas**, in Africa as **Velds** and in central Europe and Asia they are known as **Steppes.**

Winds keep blowing and evaporation rate is very high. It also favours rapid fires in summer. The soils are quite fertile and therefore, very often these grasslands are cleared for agriculture.

(*c*) **Polar grasslands (Arctic Tundra):** They are found in arctic polar region where severe cold and strong, frigid winds along with ice and snow create too harsh a climate for trees to grow. In summers the sun-shines almost round the clock and hence several small annual plants grow in the summer. The animals include arctic wolf, weasel, arctic fox, reindeer etc. A thick layer of ice remains frozen under the soil surface throughout the year and is known as **permafrost**. In summer, the tundra shows the appearance of shallow lakes, bogs etc. where mosquitoes, different type of insects and migratory birds appear.

## ■ DESERT ECOSYSTEMS

These ecosystems occur in regions where evaporation exceeds precipitation (rainfall, snow etc.). The precipitation is less than 25 cm per year. About 1/3rd of our world's land area is covered by deserts. Deserts have little species diversity and consist of drought resistant or drought avoiding plants. The atmosphere is very dry and hence it is a poor insulator. That is why in deserts the soil gets cooled up quickly, making the nights cool. Deserts are of three major types, based on climatic conditions:

(*a*) **Tropical deserts** like Sahara and Namib in Africa and Thar desert, Rajasthan, India are the driest of all with only a few species. Wind blown sand dunes are very common.

(*b*) **Temperate deserts** like Mojave in Southern California where day time temperatures are very hot in summer but cool in winters.

(*c*) **Cold deserts** like the Gobi desert in China has cold winters and warm summers.

Desert plants and animals are having most typical adaptations for conservation of water. Many desert plants are found to have reduced, scaly leaves so as to cut down loss of water due to transpiration or have succulent leaves to store water. Many a times their stems get flattened and develop chlorophyll so that they can take up the function of photosynthesis. Some plants show very deep roots to tap the groundwater. Many plants have a waxy, thick cuticle over the leaf to reduce loss of water through transpiration. Desert animals like insects and reptiles have thick outer coverings to minimize loss of water. They usually live inside burrows where humidity is better and heat is less. Desert soil is rich in nutrients but deficient in water.

Due to low species diversity, shortage of water and slow growth rate, the desert plant communities, if faced with a severe stress take a long time to recover.

## ■ AQUATIC ECOSYSTEMS

Aquatic ecosystems dealing with water bodies and the biotic communities present in them are either freshwater or marine. Freshwater ecosystems are further of standing type (**lentic**) like ponds and lakes or free-flowing type (**lotic**), like rivers. Let us consider some important aquatic ecosystems.

(*a*) **Pond ecosystem:** It is a small freshwater aquatic ecosystem where water is stagnant. Ponds may be seasonal in nature i.e. receiving

enough water during rainy season. Ponds are usually shallow water bodies which play a very important role in the villages where most of the activities center around ponds. They contain several types of algae, aquatic plants, insects, fishes and birds. The ponds are, however, very often exposed to tremendous anthropogenic (human-generated) pressures. They are used for washing clothes, bathing, swimming, cattle bathing and drinking etc. and therefore get polluted.

(*b*) **Lake ecosystems:** Lakes are usually big freshwater bodies with standing water. They have a shallow water zone called **Littoral zone,** an open-water zone where effective penetration of solar light takes place, called **Limnetic zone** and a deep bottom area where light penetration is negligible, known as **profundal zone** (Fig. 3.16).

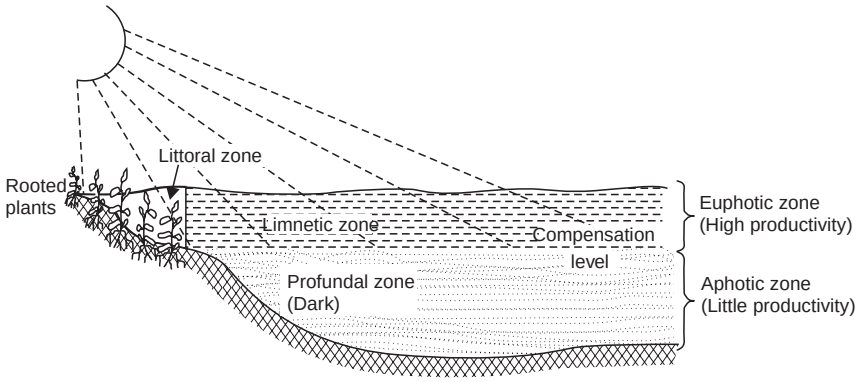



Fig. 3.16. Zonation in a lake ecosystem.

The Dal Lake in Srinagar (J & K), Naini Lake in Nainital (Uttaranchal) and Loktak lake in Manipur are some of the famous lakes of our country.

**Organisms :** The lakes have several types of organisms:

(*a*) **Planktons** that float on the surface of waters e.g. *phytoplanktons* like algae and *zooplanktons* like rotifers.

(*b*) **Nektons** that swim e.g. fishes.

(*c*) **Neustons** that rest or swim on the surface.

(*d*) **Benthos** that are attached to bottom sediments e.g. snails.

(*e*) **Periphytons** that are attached or clinging to other plants or any other surface e.g. crustaceans.

**Stratification :** The lakes show stratification or zonation based on temperature differences. During summer, the top waters become warmer than the bottom waters. Therefore, only the warm top layer

circulates without mixing with the colder layer, thus forming a distinct zonation:

**Epilimnion** : Warm, lighter, circulating surface layer

**Hypolimnion** : Cold, viscous, non-circulating bottom layer.

In between the two layers is **thermocline**, the region of sharp drop in temperature.

**Types of Lakes :** Some important types of lakes are:

(*a*) **Oligotrophic lakes** which have low nutrient concentrations.

(*b*) **Eutrophic lakes** which are overnourished by nutrients like nitrogen and phosphorus, usually as a result of agricultural run-off or municipal sewage discharge. They are covered with "algal blooms" e.g. Dal Lake.

(*c*) **Dystrophic lakes** that have low pH, high humic acid content and brown waters e.g. bog lakes.

(*d*) **Endemic lakes** that are very ancient, deep and have endemic fauna which are restricted only to that lake e.g. the Lake Baikal in Russia; the deepest lake, which is now suffering a threat due to industrial pollution.

(*e*) **Desert salt lakes** that occur in arid regions and have developed high salt concentrations as a result of high evaporation. e.g. great salt lake, Utah; Sambhar lake in Rajasthan.

(*f*) **Volcanic lakes** that receive water from magma after volcanic eruptions e.g. many lakes in Japan. They have highly restricted biota.

(*g*) **Meromictic lakes** that are rich in salts and are permanently stratified e.g. lake Nevada.

(*h*) **Artificial lakes or impoundments** that are created due to construction of dams e.g. Govindsagar lake at Bhakra-Nangal.

### Streams

These are freshwater aquatic ecosystems where water current is a major controlling factor, oxygen and nutrient in the water is more uniform and land-water exchange is more extensive. Although stream organisms have to face more extremes of temperature and action of currents as compared to pond or lake organisms, but they do not have to face oxygen deficiency under natural conditions. This is because the streams are shallow, have a large surface exposed to air and constant motion which churns the water and provides abundant oxygen. Their dissolved oxygen level is higher than that of ponds even though the green plants

are much less in number. The stream animals usually have a narrow range of tolerance to oxygen. That is the reason why they are very susceptible to any organic pollution which depletes dissolved oxygen in the water. Thus, streams are the worst victims of industrial development.

**River Ecosystem:** Rivers are large streams that flow downward from mountain highlands and flowing through the plains fall into the sea. So the river ecosystems show a series of different conditions.

**The mountain highland** part has cold, clear waters rushing down as water falls with large amounts of dissolved oxygen. The plants are attached to rocks (periphytons) and fishes are cold-water, high oxygen requiring fish like trouts.

**In the second phase** on the gentle slopes, the waters are warmer and support a luxuriant growth of plants and less oxygen requiring fishes.

**In the third phase,** the river waters are very rich in biotic diversity. Moving down the hills, rivers shape the land. They bring with them lots of silt rich in nutrients which is deposited in the plains and in the delta before reaching the ocean.

### Oceans

These are gigantic reservoirs of water covering more than 70% of our earth's surface and play a key role in the survival of about 2,50,000 marine species, serving as food for humans and other organisms, give a huge variety of sea-products and drugs. Oceans provide us iron, phosphorus, magnesium, oil, natural gas, sand and gravel.

Oceans are the major sinks of carbon dioxide and play an important role in regulating many biogeochemical cycles and hydrological cycle, thereby regulating the earth's climate.

The oceans have two major life zones: (Fig. 3.17)

**Coastal zone** with relatively warm, nutrient rich shallow water. Due to high nutrients and ample sunlight this is the zone of high primary productivity.

**Open sea:** It is the deeper part of the ocean, away from the continental shelf (The submerged part of the continent). It is vertically divided into three regions:

(*i*) **Euphotic zone** which receives abundant light and shows high photosynthetic activity.

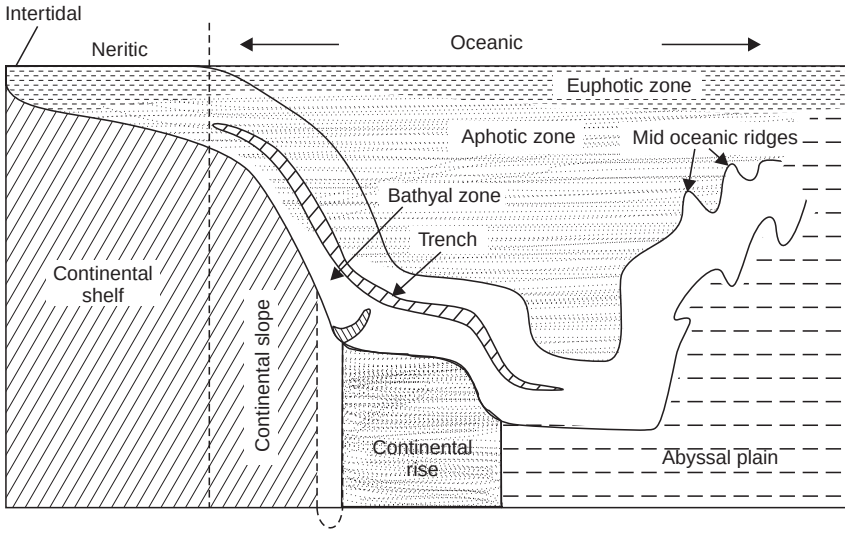



Fig. 3.17. Vertical and horizontal zonation of a marine ecosystem.

(*ii*) **Bathyal zone** receives dim light and is usually geologically active.

(*iii*) **Abyssal zone** is the dark zone, 2000 to 5000 metres deep. The abyssal zone has no primary source of energy i.e. solar energy. It is the world's largest ecological unit but it is an incomplete ecosystem.

## Estuary

An estuary is a partially enclosed coastal area at the mouth of a river where fresh water and salty seawater meet. These are the transition zones which are strongly affected by tidal action. Constant mixing of water stirs up the silt which makes the nutrients available for the primary producers. There are wide variations in the stream flow and tidal currents at any given location diurnally, monthly and seasonally. Therefore, the organisms present in estuaries show a wide range of tolerance to temperature and salinity. Such organisms are known as **eurythermal** and **euryhaline**. Coastal bays, and tidal marshes are examples of estuaries.

Estuaries have a rich biodiversity and many of the species are endemic. There are many migratory species of fishes like eels and salmons in which half of the life is spent in fresh water and half in salty water. For them estuaries are ideal places for resting during migration, where they also get abundant food. Estuaries are highly productive ecosystems. The river flow and tidal action provide energy subsidies for the estuary thereby enhancing its productivity. Estuaries are of much use

to human beings due to their high food potential. However, these ecosystems need to be managed judiciously and protected from pollution.

## QUESTIONS

**1.** Define ecology and ecosystems.
**2.** What are the biotic and abiotic components of an ecosystem ?
**3.** What are food chains and food webs ? Give examples and discuss their significance.
**4.** What are ecological pyramids ? Explain why some of these pyramids are upright while others are inverted in different ecosystems.
**5.** Discuss the models of energy flow in an ecosystem.
**6.** What are biogeochemical cycles ? Explain with the help of a diagram the nitrogen cycle.
**7.** Define primary production and secondary production. Why are tropical wet forests and estuaries most productive ?
**8.** What is homeostasis ? What are feedback mechanisms ?
**9.** Discuss the process of ecological succession.
**10.** Write short notes on (*a*) tropical rain forests (*b*) Savannas (*c*) Arctic Tundra.
**11.** What are the different zones in a lake ecosystem ?
**12.** What do you mean by the following :
(*a*) Thermocline (*b*) Oligotrophic Lakes
(*c*) Meromictic Lakes.
**13.** Discuss the major features of a stream (river) that differ from that of a lake.
**14.** Discuss zonation in an ocean. What role is played by oceans in terms of providing resources and regulating climate ?
**15.** Discuss the salient features of an estuarine ecosystem.

Unit

# 4 Biodiversity and its Conservation

If we divide the whole earth's mass into 10 billion parts, it is only in one part where life exists and the astounding variety of living organisms numbering somewhere around 50 million species are all restricted to just about a kilometer- thick layer of soil, water and air. Isn't it wonderful to see that so much diversity has been created by nature on this earth from so little physical matter!

**Biodiversity refers to the variety and variability among all groups of living organisms and the ecosystem complexes in which they occur.** From the driest deserts to the dense tropical rainforests and from the high snow-clad mountain peaks to the deepest of ocean trenches, life occurs in a marvellous spectrum of forms, size, colour and shape, each with unique ecological inter-relationships. Just imagine how monotonous and dull the world would have been had there been only a few species of living organisms that could be counted on fingertips!

**In the Convention of Biological diversity (1992) biodiversity has been defined as the variability among living organisms from all sources including *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part.**

## Levels of Biodiversity

Units of biodiversity may range from the genetic level within a species to the biota in a specific region and may extend up to the great diversity found in different biomes.

### ■ GENETIC DIVERSITY

It is the basic source of biodiversity. The genes found in organisms can form enormous number of combinations each of which gives rise to some variability. Genes are the basic units of hereditary information transmitted from one generation to other. When the genes within the same species show different versions due to new combinations, it is called genetic variability. For example, all rice varieties belong to the

species *Oryza sativa*, but there are thousands of wild and cultivated varieties of rice which show variations at the genetic level and differ in their color, size, shape, aroma and nutrient content of the grain. This is the genetic diversity of rice.

## ■ SPECIES DIVERSITY

This is the variability found within the population of a species or between different species of a community. It represents broadly the species richness and their abundance in a community. There are two popular indices of measuring species diversity known as *Shannon-Wiener index* and *Simpson index*.

What is the number of species on this biosphere? The estimates of actual number vary widely due to incomplete and indirect data. The current estimates given by Wilson in 1992 put the total number of living species in a range of 10 million to 50 million. Till now only about 1.5 million living and 300,000 fossil species have been actually described and given scientific names. It is quite likely that a large fraction of these species may become extinct even before they are discovered and enlisted.

## ■ ECOSYSTEM DIVERSITY

This is the diversity of ecological complexity showing variations in ecological niches, trophic structure, food-webs, nutrient cycling etc. The ecosystems also show variations with respect to physical parameters like moisture, temperature, altitude, precipitation etc. Thus, there occurs tremendous diversity within the ecosystems, along these gradients. We may consider diversity in forest ecosystem, which is supposed to have mainly a dominance of trees. But, while considering a tropical rainforest, a tropical deciduous forest, a temperate deciduous forest and a boreal forest, the variations observed are just too many and they are mainly due to variations in the above mentioned physical factors. The ecosystem diversity is of great value that must be kept intact. This diversity has developed over millions of years of evolution. If we destroy this diversity, it would disrupt the ecological balance. We cannot even replace the diversity of one ecosystem by that of another. Coniferous trees of boreal forests cannot take up the function of the trees of tropical deciduous forest lands and vice versa, because ecosystem diversity has evolved with respect to the prevailing environmental conditions with well-regulated ecological balance.

## ■ BIOGEOGRAPHICAL CLASSIFICATION OF INDIA

India has different types of climate and topography in different parts of the country and these variations have induced enormous variability in flora and fauna. India has a rich heritage of biological diversity and occupies the tenth position among the plant rich nations of the world.

It is very important to study the distribution, evolution, dispersal and environmental relationship of plants and animals in time and space. **Biogeography** comprising of phytogeography and zoogeography deals with these aspects of plants and animals. In order to gain insight about the distribution and environmental interactions of flora and fauna of our country, it has been classified into ten biogeographic zones (Table 4.1). Each of these zones has its own characteristic climate, soil, topography and biodiversity.

**Table 4.1. India's major biogeographic habitats**

| Sr. No. | Biogeographic Zone | Biotic Province | Total area (Sq. Km.) |
|---|---|---|---|
| 1. | Trans-Himalayan | Upper Regions | 186200 |
| 2. | Himalayan | North-West Himalayas<br>West Himalayas<br>Central Himalayas<br>East Himalayas | 6900<br>720000<br>123000<br>83000 |
| 3. | Desert | Kutch<br>Thar<br>Ladakh | 45000<br>180000<br>NA |
| 4. | Semi-Arid | Central India<br>Gujarat-Rajwara | 107600<br>400400 |
| 5. | Western Ghats | Malabar Coast<br>Western Ghat Mountains | 59700<br>99300 |
| 6. | Deccan Peninsula | Deccan Plateau South<br>Central Plateau<br>Eastern Plateau<br>Chhota Nagpur<br>Central Highlands | 378000<br>341000<br>198000<br>217000<br>287000 |
| 7. | Gangetic Plain | Upper Gangetic Plain<br>Lower Gangetic Plain | 206400<br>153000 |

| | | | |
|---|---|---|---|
| 8. | North-East India | Brahmaputra Valley<br>North-Eastern Hills | 65200<br>106200 |
| 9. | Islands | Andaman Islands<br>Nicobar Islands<br>Lakshadweep Islands | 6397<br>1930<br>180 |
| 10. | Coasts | West Coast<br>East Coast | 6500<br>6500 |

**Source:** "Conserving our Biological Wealth", WWF for Nature-India and Zoological Survey of India.

## ■ VALUE OF BIODIVERSITY

The value of biodiversity in terms of its commercial utility, ecological services, social and aesthetic value is enormous. We get benefits from other organisms in innumerable ways. Sometimes we realize and appreciate the value of the organism only after it is lost from this earth. Very small, insignificant, useless looking organism may play a crucial role in the ecological balance of the ecosystem or may be a potential source of some invaluable drug for dreaded diseases like cancer or AIDS. The multiple uses of biodiversity or biodiversity value has been classified by McNeely *et al* in 1990 as follows:

(*i*) **Consumptive use value**: These are direct use values where the biodiversity product can be harvested and consumed directly e.g. fuel, food, drugs, fibre etc.

**Food:** A large number of wild plants are consumed by human beings as food. About 80,000 edible plant species have been reported from wild. About 90% of present day food crops have been domesticated from wild tropical plants. Even now our agricultural scientists make use of the existing wild species of plants that are closely related to our crop plants for developing new hardy strains. Wild relatives usually possess better tolerance and hardiness. A large number of wild animals are also our sources of food.

**Drugs and medicines:** About 75% of the world's population depends upon plants or plant extracts for medicines. The wonder drug ***Penicillin*** used as an antibiotic is derived from a fungus called *Penicillium*. Likewise, we get ***Tetracyclin*** from a bacterium. Quinine, the cure for malaria is obtained from the bark of ***Cinchona*** tree, while *Digitalin* is obtained from foxglove (***Digitalis***) which is an effective cure for heart ailments. Recently ***vinblastin*** and ***vincristine***, two anticancer drugs, have been obtained from Periwinkle (*Catharanthus*) plant, which

possesses anticancer alkaloids. A large number of marine animals are supposed to possess anti-cancer properties which are yet to be explored systematically.

**Fuel:** Our forests have been used since ages for fuel wood. The fossil fuels coal, petroleum and natural gas are also products of fossilized biodiversity. Firewood collected by individuals are not normally marketed, but are directly consumed by tribals and local villagers, hence falls under consumptive value.

(*ii*) **Productive use values:** These are the commercially usable values where the product is marketed and sold. It may include lumber or wild gene resources that can be traded for use by scientists for introducing desirable traits in the crops and domesticated animals. These may include the animal products like tusks of elephants, musk from musk deer, silk from silk-worm, wool from sheep, fir of many animals, lac from lac insects etc, all of which are traded in the market. Many industries are dependent upon the productive use values of biodiversity e.g.- the paper and pulp industry, Plywood industry, Railway sleeper industry, Silk industry, textile industry, ivory-works, leather industry, pearl industry etc.

Despite international ban on trade in products from endangered species, smuggling of fur, hide, horns, tusks, live specimen etc. worth millions of dollars are being sold every year. Developing countries in Asia, Africa and Latin America are the richest biodiversity centers and wild life products are smuggled and marketed in large quantities to some rich western countries and also to China and Hong Kong where export of cat skins and snake skins fetches a booming business.

(*iii*) **Social Value:** These are the values associated with the social life, customs, religion and psycho-spiritual aspects of the people. Many of the plants are considered holy and sacred in our country like Tulsi (holy basil), Peepal, Mango, Lotus, Bael etc. The leaves, fruits or flowers of these plants are used in worship or the plant itself is worshipped. The tribal people are very closely linked with the wild life in the forests. Their social life, songs, dances and customs are closely woven around the wildlife. Many animals like Cow, Snake, Bull, Peacock, Owl etc. also have significant place in our psycho-spiritual arena and thus hold special social importance. Thus biodiversity has distinct social value, attached with different societies.

(*iv*) **Ethical value**: It is also sometimes known as **existence value**. It involves ethical issues like "*all life must be preserved*". It is based on the concept of "*Live and Let Live*". If we want our human race to survive, then we must protect all biodiversity, because biodiversity is valuable.

The ethical value means that we may or may not use a species, but knowing the very fact that this species exists in nature gives us pleasure. We all feel sorry when we learn that "passenger pegion" or "dodo" is no more on this earth. We are not deriving anything direct from Kangaroo, Zebra or Giraffe, but we all strongly feel that these species should exist in nature. This means, there is an ethical value or existence value attached to each species.

(*v*) **Aesthetic value:** Great aesthetic value is attached to biodiversity. No one of us would like to visit vast stretches of barren lands with no signs of visible life. People from far and wide spend a lot of time and money to visit wilderness areas where they can enjoy the aesthetic value of biodiversity and this type of tourism is now known as ***eco-tourism***. The "***Willingness to pay***" concept on such eco-tourism gives us even a monetary estimate for aesthetic value of biodiversity. Ecotourism is estimated to generate about 12 billion dollars of revenue annually, that roughly gives the aesthetic value of biodiversity.

(*vi*) **Option values:** These values include the potentials of biodiversity that are presently unknown and need to be explored. There is a possibility that we may have some potential cure for AIDS or cancer existing within the depths of a marine ecosystem, or a tropical rainforest.

Thus option value is the value of knowing that there are biological resources existing on this biosphere that may one day prove to be an effective option for something important in the future. Thus, the option value of biodiversity suggests that any species may prove to be a miracle species someday. The biodiversity is like precious gifts of nature presented to us. We should not commit the folly of losing these gifts even before unwrapping them.

The option value also includes the values, in terms of the option to visit areas where a variety of flora and fauna, or specifically some endemic, rare or endangered species exist.

(*vii*) **Ecosystem service value:** Recently, a non-consumptive use value related to self maintenance of the ecosystem and various important ecosystem services has been recognized. It refers to the services provided by ecosystems like prevention of soil erosion, prevention of floods, maintenance of soil fertility, cycling of nutrients, fixation of nitrogen, cycling of water, their role as carbon sinks, pollutant absorption and reduction of the threat of global warming etc.

Different categories of biodiversity value clearly indicate that ecosystem, species and genetic diversity all have enormous potential and a decline in biodiversity will lead to huge economic, ecological and socio-cultural losses.

**Biodiversity value of some selected organisms in monetary terms**

- A male lion living upto an age of 7 years can generate upto $ 515,000 due to its aesthetic value as paid by tourists, whereas if killed for the lion skin a market price upto $ 1,000 can be fetched.
- In its lifetime a Kenyan elephant can earn worth $ 1 million as tourist revenue.
- The mountain gorillas in Rwanda are fetching $ 4 million annually through eco-tourism.
- Whale watching on Hervey Bay on Queensland's coast earns $12 million annually.
- Tourism to Great Barrier Reef in Australia earns $ 2 billion each year.
- A typical tree provides $ 196,2150 worth of ecological services as oxygen, clean air, fertile soil, erosion control, water recycling, wildlife habitat, toxic gas moderation etc. Whereas its worth is only about $ 590 if sold in the market as timber.

## ■ GLOBAL BIODIVERSITY

Following the 1992 "Earth Summit" at Rio de Janeiro, it became evident that there is a growing need to know and scientifically name, the huge number of species which are still unknown on this earth. Roughly 1.5 million species are known till date which is perhaps 15% or may be just 2% of the actual number. Tropical deforestation alone is reducing the biodiversity by half a percent every year. Mapping the biodiversity has therefore, been rightly recognized as an emergency task in order to plan its conservation and practical utilization in a judicious manner.

**Terrestrial biodiversity** of the earth is best described as ***biomes***, which are the largest ecological units present in different geographic areas and are named after the dominant vegetation e.g. the tropical rainforests, tall grass prairies, savannas, desert, tundra etc.

The tropical rainforests are inhabited by teeming millions of species of plants, birds, amphibians, insects as well as mammals. They are the earth's largest storehouse of biodiversity. Many of these species have developed over the time in highly specialized niches and that makes them more vulnerable to extinction when their natural home or niche is destroyed. About 50 to 80% of global biodiversity lies in these rainforests. More than one-fourth of the world's prescription drugs are extracted from plants growing in tropical forests. Out of the 3000 plants identified by National Cancer Research Institute as sources of cancer

fighting chemicals, 70% come from tropical rain forests. Very recently, extract from one of the creeping vines in the rainforests at Cameroon has proved effective in the inhibition of replication of AIDS virus. It is interesting to note that the common Neem tree, so popular in tropical India, known for its medicinal properties has now come into lime light even in the western temperate countries.

There is an estimated 1,25,000 flowering plant species in tropical forests. However, till now we know only 1-3% of these species. Needless to say, we must try in every way to protect our tropical rainforests. The Silent Valley in Kerala is the only place in India where tropical rain forests occur. You may recall the case of Silent Valley Hydroelectric Project, which was abandoned mainly because it had put to risk our only tropical rain forest biodiversity.

Temperate forests have much less biodiversity, but there is much better documentation of the species. Globally, we have roughly 1,70,000 flowering plants, 30,000 vertebrates and about 2,50,000 other groups of species that have been described. There is a stupendous task of describing the remaining species which may range anywhere from 8 million to 100 million.

Table 4.2 shows the estimated number of some known living species in different taxonomic groups:

**Table 4.2 Living species estimates (World Resource Institute, 1999)**

| Taxonomic group | Number |
|---|---|
| Bacteria & Cyanobacteria | 5,000 |
| Protozoans (Single called animals) | 31,000 |
| Algae | 27,000 |
| Fungi (Molds, Mushrooms) | 45,000 |
| Higher Plants | 2,50,000 |
| Sponges | 5,000 |
| Jelly fish, Corals etc. | 10,000 |
| Flatworms, roundworms, earthworms | 36,000 |
| Snails, Clams, Slugs etc | 70,000 |
| Insects | 7,50,000 |
| Mites, Ticks, Croaks, shrimps | 1,20,000 |
| Fish and Sharks | 22,000 |
| Amphibians | 4,000 |
| Reptiles | 5,000 |
| Birds | 9,000 |
| Mammals | 4,000 |
| Total | 1,400,000 |

It is interesting to know that marine diversity is even much higher than terrestrial biodiversity and ironically, they are still less known and described. Estuaries, coastal waters and oceans are biologically diverse and the diversity is just dazzling. Sea is the cradle of every known animal phylum. Out of the 35 existing phyla of multicellular animals, 34 are marine and 16 of these are exclusively marine.

## ■ BIOLOGICAL DIVERSITY AT NATIONAL LEVEL (Indian Biodiversity):

Every country is characterized by its own biodiversity depending mainly on its climate. India has a rich biological diversity of flora and fauna. Overall six percent of the global species are found in India. It is estimated that **India ranks 10th among the plant rich countries of the world, 11th in terms of number of endemic species of higher vertebrates and 6th among the centers of diversity and origin of agricultural crops.**

The total number of living species identified in our country is 150,000. Out of a total of 25 biodiversity hot-spots in the world, India possesses two, one in the north-east region and one in the western ghats. Indian is also one of the 12 mega-biodiversity countries in the world, which will be discussed later.

## ■ REGIONAL OR LOCAL BIODIVERSITY

Biodiversity at regional level is better understood by categorizing species richness into four types, based upon their spatial distribution as discussed below

(*i*) **Point richness** refers to the number of species that can be found at a single point in a given space.

(*ii*) **Alpha (α-) richness** refers to the number of species found in a small homogeneous area

(*iii*) **Beta (β-) richness** refers to the rate of change in species composition across different habitats.

(*iv*) **Gamma (γ-) richness** refers to the rate of change across large landscape gradients.

α-richness is strongly correlated with physical environmental variables. For example, there are 100 species of tunicates in arctic waters, 400 species in temperate waters and 600 in tropical seas. Thus, temperature seems to be the most important factor affecting α-richness of tunicates.

β-richness means that the cumulative number of species increases as more heterogeneous habitats are taken into consideration. For example, the ant species found in local regions of north pole is merely 10. As we keep on moving towards the equator and thus add more and more habitats, the number of species of ants reaches as high as 2000 on the equatorial region.

## ■ INDIA AS A MEGA-DIVERSITY NATION

India is one of the 12 megadiversity countries in the world. The Ministry of Environment and Forests, Govt. of India (2000) records 47,000 species of plants and 81,000 species of animals which is about 7% and 6.5% respectively of global flora and fauna.

**Table 4.3. Distribution of species in some major groups of flora and fauna in India**

| Group-wise species Distribution | | | |
|---|---|---|---|
| **Plants** | **Number** | **Animals** | **Number** |
| Bacteria | 850 | Lower groups | 9979 |
| Fungi | 23,000 | Mollusca | 5042 |
| Algae | 2500 | Arthropoda | 57,525 |
| Bryophytes | 2564 | Pisces (Fishes) | 2546 |
| | | Amphibia | |
| Pteridophytes | 1022 | Reptiles | 428 |
| Gymnosperms | 64 | Birds | 1228 |
| Angiosperms | 15,000 | | 204 |
| | | Mammals | 372 |

**Endemism:** Species which are restricted only to a particular area are known as endemic. India shows a good number of endemic species. About 62% of amphibians and 50% of lizards are endemic to India. Western ghats are the site of maximum endemism.

**Center of origin:** A large number of species are known to have originated in India. Nearly 5000 species of flowering plants had their origin in India. From agro-diversity point of view also our country is quite rich. India has been the center of origin of 166 species of crop plants and 320 species of wild relatives of cultivated crops, thereby providing a broad spectrum of diversity of traits for our crop plants.

**Marine diversity:** Along 7500 km long coastline of our country in the mangroves, estuaries, coral reefs, back waters etc. there exists a

rich biodiversity. More than 340 species of corals of the world are found here. The marine diversity is rich in mollusks, crustaceans (crabs etc.), polychaetes and corals. Several species of Mangrove plants and seagrasses (Marine algae) are also found in our country.

A large proportion of the Indian Biodiversity is still unexplored. There are about 93 major wet lands, coral reefs and mangroves which need to be studied in detail. Indian forests cover 64.01 million hectares having a rich biodiversity of plants in the Trans-Himalayan, north-west, west, central and eastern Himalayan forests, western ghats, coasts, deserts, Gangetic plains, deccan plateau and the Andaman, Nicobar and Lakshadweep islands. Due to very diverse climatic conditions there is a complete rainbow spectrum of biodiversity in our country.

## ■ HOT SPOTS OF BIODIVERSITY

***Areas which exhibit high species richness as well as high species endemism are termed as hot spots of biodiversity.*** The term was introduced by Myers (1988). There are 25 such hot spots of biodiversity on a global level out of which two are present in India, namely the Eastern Himalayas and Western Ghats (Table 4.4).

These hotspots covering less than 2% of the world's land area are found to have about 50% of the terrestrial biodiversity. According to Myers *et al*. (2000) an area is designated as a hotspot when it contains at least 0.5% of the plant species as endemics.

About 40% of terrestrial plants and 25% of vertebrate species are endemic and found in these hotspots. After the tropical rain forests, the second highest number of endemic plant species are found in the Mediterranean (Mittermeier). Broadly, these hot spots are in Western Amazon, Madagascar, North and East Borneo, North Eastern Australia, West Africa and Brazilian Atlantic forests. These are the areas of high diversity, endemism and are also threatened by human activities. More than 1 billion people (about 1/6th of the world's population) most of whom are desperately poor people, live in these areas. Any measures of protecting these hotspots need to be planned keeping in view the human settlements and tribal issues.

Earlier 12 hot spots were identified on a global level. Later Myers *et al* (2000) recognized 25 hot spots as shown in Table 4.3. Two of these hotspots lie in India extending into neighbouring countries namely, Indo-Burma region (covering Eastern Himalayas) and Western Ghats - Sri Lanka region. The Indian hot spots are not only rich in floral wealth and endemic species of plants but also reptiles, amphibians, swallow tailed butterflies and some mammals.

**Table 4.4. Global hotspots of biodiversity**

| Hotspots | Plant Species | Endemic Plants | % of Global Plants | Vertebrate Species | Endemic Vertebrates | % of Global Vertebrates |
|---|---|---|---|---|---|---|
| 1. Tropical Andes | 45000 | 20000 | 6.7 | 3389 | 1567 | 5.7 |
| 2. Mesoamerican forests | 24000 | 5000 | 1.7 | 2859 | 1159 | 4.2 |
| 3. Caribbean | 12000 | 7000 | 2.3 | 1518 | 779 | 2.9 |
| 4. Brazil's Atlantic Forest | 20000 | 8000 | 2.7 | 1361 | 567 | 2.1 |
| 5. Choc/Darien of Panama Western Ecuador | 9000 | 2250 | 0.8 | 1625 | 418 | 1.5 |
| 6. Brazil's Cerrado | 10000 | 4400 | 1.5 | 1268 | 117 | 0.4 |
| 7. Central Chile | 3429 | 1605 | 0.5 | 335 | 61 | 0.2 |
| 8. California Floristic Province | 4426 | 2125 | 0.7 | 584 | 71 | 0.3 |
| 9. Madagascar | 12000 | 9704 | 3.2 | 987 | 771 | 2.8 |
| 10. Eastern Arc and Coastal Forest of Tanzania/Kenya | 4000 | 1500 | 0.5 | 1019 | 121 | 0.4 |
| 11. Western African Forests | 9000 | 2250 | 0.8 | 1320 | 270 | 1.0 |

| Hotspots | Plant Species | Endemic Plants | % of Global Plants | Vertebrate Species | Endemic Vertebrates | % of Global Vertebrates |
|---|---|---|---|---|---|---|
| 12. Cape Floristic Province | 8200 | 5682 | 1.9 | 562 | 53 | 0.2 |
| 13. Succulent Karoo | 4849 | 1940 | 0.6 | 472 | 45 | 0.2 |
| 14. Mediterranean Basin | 25000 | 13000 | 4.3 | 770 | 235 | 0.9 |
| 15. Caucasus | 6300 | 1600 | 0.5 | 632 | 59 | 0.2 |
| 16. Sundaland | 25000 | 15000 | 5.0 | 1800 | 701 | 2.6 |
| 17. Wallacea | 10000 | 1500 | 0.5 | 1142 | 529 | 1.9 |
| 18. Philippines | 7620 | 5832 | 1.9 | 1093 | 518 | 1.9 |
| 19. Indo-Burma Eastern Himalayas | 13500 | 7000 | 2.3 | 2185 | 528 | 1.9 |
| 20. South-Central China | 12000 | 3500 | 1.2 | 1141 | 178 | 0.7 |
| 21. Western-Ghats Sri Lanka | 4780 | 2180 | 0.7 | 1073 | 355 | 1.3 |
| 22. South-western Australia | 5469 | 4331 | 1.4 | 456 | 100 | 0.4 |
| 23. New Caledonia | 3332 | 2551 | 0.9 | 190 | 84 | 0.3 |
| 24. New Zealand | 2300 | 1865 | 0.6 | 217 | 136 | 0.5 |
| 25. Polynesia/Micronesia | 6557 | 3334 | 1.1 | 342 | 223 | 0.8 |
| **Total** | — | **133,149** | **44.4** | — | **9645** | **35.3** |

Source: Myers *et al.,* 2000.

(*a*) ***Eastern Himalayas***: They display an ultra-varied topography that fosters species diversity and endemism. There are numerous deep and semi-isolated valleys in Sikkim which are extremely rich in endemic plant species. In an area of 7298 $Km^2$ of Sikkim about 4250 plant species are found of which 60% are endemic.

The forest cover of Eastern Himalayas has dwindled to about 1/3rd of its original cover. Certain species like *Sapria himalayana*, a parasitic angiosperm was sighted only twice in this region in the last 70 years.

Recent studies have shown that North East India along with its contiguous regions of Burma and Chinese provinces of Yunnan and Schezwan is an active center of organic evolution and is considered to be the cradle of flowering plants. Out of the world's recorded flora 30% are endemic to India of which 35,000 are in the Himalayas.

(*b*) ***Western Ghats***: It extends along a 17,000 $Km^2$ strip of forests in Maharashtra, Karnataka, Tamil Nadu and Kerala and has 40% of the total endemic plant species. 62% amphibians and 50% lizards are endemic to Western Ghats.

Forest tracts upto 500 m elevation covering 20% of the forest expanse are evergreen while those in 500-1500 m range are semi-evergreen. The major centers of diversity are ***Agastyamalai Hills*** and ***Silent Valley—the New Amambalam Reserve Basin***. It is reported that only 6.8% of the original forests are existing today while the rest has been deforested or degraded, which raises a serious cause of alarm, because it means we have already lost a huge proportion of the biodiversity.

Although the hotspots are characterized by endemism, interestingly, a few species are common to both the hotspots in India. Some common plants include *Ternstroemia japonica*, *Rhododendron* and *Hypericum,* while the common fauna includes laughing thrush, Fairy blue bird, lizard hawk etc. indicating their common origin long back in the geological times.

## ■ THREATS TO BIODIVERSITY

Extinction or elimination of a species is a natural process of evolution. In the geologic period the earth has experienced mass extinctions. During evolution, species have died out and have been replaced by others. However, the rate of loss of species in geologic past has been a slow process, keeping in view the vast span of time going back to 444 million years. The process of extinction has become particularly fast in the recent years of human civilization. In this century, the human impact

has been so severe that thousands of species and varieties are becoming extinct annually. ***One of the estimates by the noted ecologist, E.O. Wilson puts the figure of extinction at 10,000 species per year or 27 per day!*** This startling figure raises an alarm regarding the serious threat to biodiversity. Over the last 150 years the rate of extinction has escalated more dramatically. If the present trend continues we would lose 1/3rd to 2/3rd of our current biodiversity by the middle of twenty first century.

Let us consider some of the major causes and issues related to threats to biodiversity.

## ■ LOSS OF HABITAT

Destruction and loss of natural habitat is the single largest cause of biodiversity loss. Billions of hectares of forests and grasslands have been cleared over the past 10,000 years for conversion into agriculture lands, pastures, settlement areas or development projects. These natural forests and grasslands were the natural homes of thousands of species which perished due to loss of their natural habitat. Severe damage has been caused to wetlands thinking them to be useless ecosystems. The unique rich biodiversity of the wetlands, estuaries and mangroves are under the most serious threat today. The wetlands are destroyed due to draining, filling and pollution thereby causing huge biodiversity loss.

Sometimes the loss of habitat is in instalments so that the habitat is divided into small and scattered patches, a phenomenon known as **habitat fragmentation**. There are many wild life species such as bears and large cats that require large territories to subsist. They get badly threatened as they breed only in the interiors of the forests. Due to habitat fragmentation many song birds are vanishing.

There has been a rapid disappearance of tropical forests in our country also, at a rate of about 0.6% per year. With the current rate of loss of forest habitat, it is estimated that 20-25% of the global flora would be lost within a few years. Marine biodiversity is also under serious threat due to large scale destruction of the fragile breeding and feeding grounds of our oceanic fish and other species, as a result of human intervention.

## ■ POACHING

Illegal trade of wildlife products by killing prohibited endangered animals i.e. poaching is another threat to wildlife. Despite international ban on trade in products from endangered species, smuggling of wildlife items like furs, hides, horns, tusks, live specimens and herbal products

worth millions of dollars per year continues. The developing nations in Asia, Latin America and Africa are the richest source of biodiversity and have enormous wealth of wildlife. The rich countries in Europe and North America and some affluent countries in Asia like Japan, Taiwan and Hong Kong are the major importers of the wild life products or wild life itself.

The trading of such wild life products is highly profit making for the poachers who just hunt these prohibited wild life and smuggle it to other countries mediated through a mafia. ***The cost of elephant tusks can go upto $ 100 per kg; the leopard fur coat is sold at $ 100,000 in Japan while bird catchers can fetch upto $ 10,000 for a rare hyacinth macaw, a beautiful coloured bird, from Brazil***. The worse part of the story is that for every live animal that actually gets into the market, about 50 additional animals are caught and killed.

If you are fond of rare plants, fish or birds, please make sure that you are not going for the endangered species or the wild-caught species. Doing so will help in checking further decline of these species. Also do not purchase furcoat, purse or bag, or items made of crocodile skin or python skin. You will certainly help in preserving biodiversity by doing so.

## ■ MAN-WILDLIFE CONFLICTS

We have discussed about the need to preserve and protect our wildlife. However, sometimes we come across conflicting situations when wildlife starts causing immense damage and danger to man and under such conditions it becomes very difficult for the forest department to pacify the affected villagers and gain local support for wild-life conservation.

Instances of man animal conflicts keep on coming to lime light from several states in our country. In Sambalpur, Orissa 195 humans were killed in the last 5 years by elephants. In retaliation the villagers killed 98 elephants and badly injured 30 elephants. Several instances of killing of elephants in the border regions of Kote-Chamarajanagar belt in Mysore have been reported recently. The man-elephant conflict in this region has arisen because of the massive damage done by the elephants to the farmer's cotton and sugarcane crops. The agonized villagers electrocute the elephants and sometimes hide explosives in the sugarcane fields, which explode as the elephants intrude into their fields. In fact, more killings are done by locals than by poachers. Recently, in early 2004, a man-eating tiger was reported to kill 16 Nepalese people and one 4-year old child inside the Royal Chitwan

National Park, 240 Km South-west of Kathmandu. The Park renowned for its wildlife conservation effort has became a zone of terror for the locals. At times, such conflicting situations have been reported from the border regions of Corbett, Dudhwa, Palamau and Ranthambore National Parks in our country as well. Very recently in June, 2004 two men were killed by leopards in Powai, Mumbai. A total of 14 persons were killed during 19 attacks since January by the leopards from the Sanjay Gandhi National Park, Mumbai which has created a panic among the local residents.

**Causes of Man-animal conflicts:** The root causes of these conflicts are discussed below:

(*i*) Dwindling habitats of tigers, elephants, rhinos and bears due to shrinking forest cover compels them to move outside the forest and attack the field or sometimes even humans. Human encroachment into the forest areas raises a conflict between man and the wildlife, perhaps because it is an issue of survival of both.

(*ii*) Usually the ill, weak and injured animals have a tendency to attack man. Also, the female tigress attacks the human if she feels that her newborn cubs are in danger. But the biggest problem is that if human-flesh is tasted once then the tiger does not eat any other animal. At the same time, it is very difficult to trace and cull the man-eating tiger and in the process many innocent tigers are also killed.

(*iii*) Earlier, forest departments used to cultivate paddy, sugarcane etc. within the sanctuaries when the favourite staple food of elephants i.e. bamboo leaves were not available. Now due to lack of such practices the animals move out of the forest in search of food. It may be noted that, One adult elephant needs 2 quintals of green fodder and 150 kg of clean water daily and if it is not available, the animal strays out.

(*iv*) Very often the villagers put electric wiring around their ripe crop fields. The elephants get injured, suffer in pain and turn violent.

(*v*) Earlier there used to be wild-life corridors through which the wild animals used to migrate seasonally in groups to other areas. Due to development of human settlements in these corridors, the path of wildlife has been disrupted and the animals attack the settlements.

(*vi*) The cash compensation paid by the government in lieu of the damage caused to the farmers crop is not enough. In Mysore, a farmer gets a compensation of Rs. 400/- per quintal of expected yield while the market price is Rs. 2400/- per quintal. The agonized farmer therefore gets revengeful and kills the wild animals.

### Remedial Measures to Curb the Conflict

(*i*) Tiger Conservation Project (TCP) has made provisions for making available vehicles, tranquillizer guns, binoculars and radio sets etc. to tactfully deal with any imminent danger.

(*ii*) Adequate crop compensation and cattle compensation scheme must be started, along with substantial cash compensation for loss of human life.

(*iii*) Solar powered fencing should be provided along with electric current proof trenches to prevent the animals from straying into fields.

(*iv*) Cropping pattern should be changed near the forest borders and adequate fodder, fruit and water should be made available for the elephants within forest zones.

(*v*) Wild life corridors should be provided for mass migration of big animals during unfavorable periods. About 300 $km^2$ area is required for elephant corridors for their seasonal migration.

(*vi*) In Similipal Sanctuary, Orissa there is a ritual of wild animal hunting during the months of April-May for which forest is burnt to flush out the animals. Due to massive hunting by people, there is a decline in prey of tigers and they start coming out of the forest in search of prey. Now there is WWF-TCP initiative to curb this ritual of "Akhand Shikar" in Orissa.

## ■ ENDANGERED SPECIES OF INDIA

The **International Union for Conservation of Nature and Natural Resources (IUCN)** publishes the **Red Data Book** which includes the list of endangered species of plants and animals. The red data symbolizes the warning signal for those species which are endangered and if not protected are likely to become extinct in near future.

In India, nearly 450 plant species have been identified in the categories of endangered, threatened or rare. Existence of about 150 mammals and 150 species of birds is estimated to be threatened while an unknown number of species of insects are endangered. It may not be of direct relevance here to give a complete list of endangered flora and fauna of our country. However, a few species of endangered reptiles, birds, mammals and plants are given below:

| | | |
|---|---|---|
| (*a*) Reptiles | : | Gharial, green sea turtle, tortoise, python |
| (*b*) Birds | : | Great Indian bustard, Peacock, Pelican, Great Indian Hornbill, Siberian White Crane |

| | | |
|---|---|---|
| (*c*) Carnivorous Mammals | : | Indian wolf, red fox, Sloth bear, red panda, tiger, leopard, striped hyena, Indian lion, golden cat, desert cat, dugong |
| (*d*) Primates | : | Hoolock gibbon, lion-tailed macaque, Nilgiri langur, Capped monkey, golden monkey |
| (*e*) Plants | : | A large number of species of orchids, Rhododendrons, medicinal plants like *Rauvolfia serpentina*, the sandal wood tree *Santalum*, *Cycas beddonei* etc. |

The Zoological Survey of India reported that Cheetah, Pink headed duck and mountain quail have already become extinct from India.

- A species is said to be ***extinct*** when it is not seen in the wild for 50 years at a stretch e.g. Dodo, passenger pigeon.
- A species is said to be ***endangered*** when its number has been reduced to a critical level or whose habitats, have been drastically reduced and if such a species is not protected and conserved, it is in immediate danger of extinction.
- A species is said to be in ***vulnerable*** category if its population is facing continuous decline due to overexploitation or habitat destruction. Such a species is still abundant, but under a serious threat of becoming endangered if causal factors are not checked.
- Species which are not endangered or vulnerable at present, but are at a risk are categorized as ***rare*** species. These taxa are usually localized within restricted areas i.e. they are usually endemic. Sometimes they are thinly scattered over a more extensive area.

Some important endangered and extinct species are shown in Plate IV.

Passenger pigeon

Dodo

**Extinct**

Spotted owl

Tortoise

The Great Indian Bustard

Black rhinoceros

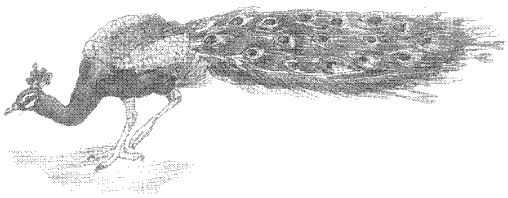
Dugong

Red panda

Green sea turtle

Tiger

Snow leopard



Peacock

Cheetah

**Endangered**

Plate IV. Some important extinct and endangered Indian species of animals.

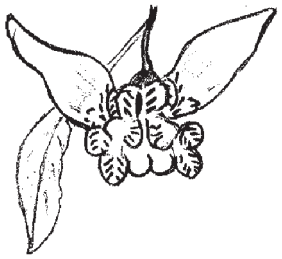
## ■ ENDEMIC SPECIES OF INDIA

India has two biodiversity hot spots and thus possesses a large number of endemic species. Out of about 47,000 species of plants in our country 7000 are endemic. Thus, Indian subcontinent has about 62% endemic flora, restricted mainly to Himalayas, Khasi Hills and Western Ghats. Some of the important endemic flora include orchids and species like *Sapria himalayana*, *Uvaria lurida, Nepenthes khasiana, Pedicularis perroter* etc. Some endemic plant species are shown in Plate V.

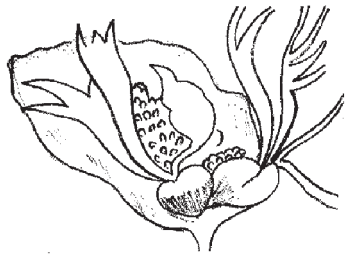
A large number out of a total of 81,000 species of animals in our country is endemic. The western ghats are particularly rich in amphibians (frogs, toads etc.) and reptiles (lizards, crocodiles etc.). About 62% amphibians and 50% lizards are endemic to Western Ghats. Different species of monitor lizards (*Varanus*), reticulated python and Indian Salamander and Viviparous toad *Nectophhryne* are some important endemic species of our country.

Toothbrush orchid
endemic to Sikkim

*Nepenthes khasiana*
(Pitcher plant)
Endangered and endemic



An endangered
endemic orchid of
Eastern Himalayas



*Platycerium*, rare and
endemic to Manipur

Plate V. Some endemic and endangered plants.

## ■ CONSERVATION OF BIODIVERSITY

The enormous value of biodiversity due to their genetic, commercial, medical, aesthetic, ecological and optional importance emphasizes the need to conserve biodiversity. Gradually we are coming to realize that wildlife is not just 'a game to be hunted', rather it is a 'gift of nature' to be nurtured and enjoyed. A number of measures are now being taken the world over to conserve biodiversity including plants and wildlife.

There are two approaches of biodiversity conservation:

(*a*) *In situ* conservation (within habitat): This is achieved by protection of wild flora and fauna in nature itself. e.g. Biosphere Reserves, National Parks, Sanctuaries, Reserve Forests etc.

(*b*) *Ex situ* conservation (outside habitats) This is done by establishment of gene banks, seed banks, zoos, botanical gardens, culture collections etc.

### *In Situ* Conservation

At present we have 7 major Biosphere reserves, 80 National Parks, 420 wild-life sanctuaries and 120 Botanical gardens in our country covering 4% of the geographic area.

The ***Biosphere Reserves*** conserve some representative ecosystems as a whole for long-term in situ conservation. In India we have Nanda Devi (U.P.), Nokrek (Meghalaya), Manas (Assam), Sunderbans (West Bengal), Gulf of Mannar (Tamil Nadu), Nilgiri (Karnataka, Kerala, Tamil Nadu), Great Nicobars and Similipal (Orrisa) biosphere Reserves. Within the Biosphere reserves we may have one or more National Parks. For example, Nilgiri Biosphere Reserve has two National Parks *viz*. Bandipur and Nagarhole National Park.

A **National Park** is an area dedicated for the conservation of wildlife along with its environment. It is also meant for enjoyment through tourism but without impairing the environment. Grazing of domestic animals, all private rights and forestry activities are prohibited within a National Park. Each National Park usually aims at conservation specifically of some particular species of wildlife along with others. Some major National Parks of our country are enlisted in the Table 4.5 below:

**Table 4.5. Some important National parks in India**

| Name of National Park | State | Important Wildlife |
|---|---|---|
| Kaziranga | Assam | One horned Rhino |
| Gir National Park | Gujarat | Indian Lion |
| Dachigam | J & K | Hangul |
| Bandipur | Karnataka | Elephant |
| Periyar | Kerala | Elephant, Tiger |
| Kanha | M.P. | Tiger |
| Corbett | U.P. | Tiger |
| Dudwa | U.P. | Tiger |
| Ranthambore | Rajasthan | Tiger |
| Sariska | Rajasthan | Tiger |

**Wildlife sanctuaries** are also protected areas where killing, hunting, shooting or capturing of wildlife is prohibited except under the control of highest authority. However, private ownership rights are permissible and forestry operations are also permitted to an extent that they do not affect the wildlife adversely.

Some major wildlife sanctuaries of our country are shown in Table 4.6.

**Table 4.6. Some Important Wildlife Sanctuaries of India**

| Name of Sanctuary | State | Major Wild Life |
|---|---|---|
| Ghana Bird Sanctuary | Rajasthan | 300 species of birds (including migratory) |
| Hazaribagh Sanctuary | Bihar | Tiger, Leopard |
| Sultanpur Bird Sanctuary | Haryana | Migratory birds |
| Nal Sarovar Bird Sanctuary | Gujarat | Water birds |
| Abohar Wildlife Sanctuary | Punjab | Black buck |
| Mudamalai Wildlife Sanctuary | Tamil Nadu | Tiger, elephant, Leopard |
| Vedanthangal Bird Sanctuary | Tamil Nadu | Water birds |
| Jaldapara Wild Life Sanctuary | W. Bengal | Rhinoceros, elephant, Tiger |
| Wild Ass Sanctuary | Gujarat | Wild ass, wolf, nilgai, chinkara |

For plants, there is one gene sanctuary for Citrus (Lemon family) and one for pitcher plant (an insect eating plant) in Northeast India. For the protection and conservation of certain animals, there have been specific projects in our country e.g. Project Tiger, Gir Lion Project, Crocodile Breeding Project, Project Elephant, Snow Leopard Project etc.

***Ex situ* Conservation:** This type of conservation is mainly done for conservation of crop varieties, the wild relatives of crops and all the local varieties with the main objective of conserving the total genetic variability of the crop species for future crop improvement or afforestation programmes. In India, we have the following important **gene bank/seed bank** facilities:

(*i*) **National Bureau of Plant Genetic Resources (NBPGR)** is located in New Delhi. Here agricultural and horticultural crops and their wild relatives are preserved by ***cryo-preservation*** of seeds, pollen etc. by using liquid nitrogen at a temperature as low as -196°C. Varieties of rice, pearl millet, Brassica, turnip, radish, tomato, onion, carrot, chilli, tobacco, poppy etc. have been preserved successfully in liquid nitrogen for several years without losing seed viability.

(*ii*) **National Bureau of Animal Genetic Resources (NBAGR)** located at Karnal, Haryana. It preserves the semen of domesticated bovine animals.

(*iii*) **National Facility for Plant Tissue Culture Repository (NFPTCR)** for the development of a facility of conservation of varieties of crop plants/trees by tissue culture. This facility has been created within the NBPGR.

The G-15 countries have also resolved to set up a network of gene banks to facilitate the conservation of various varieties of aromatic and medicinal plants for which India is the networking co-ordinator country.

## QUESTIONS

1. Define biodiversity. Explain genetic diversity, species diversity and ecosystem diversity.
2. What do your mean by consumptive use value, productive use value, social value, ethical value and option value of biodiversity ?
3. What is meant by alpha, beta and gamma richness ? Discuss, giving examples.
4. Comment upon Indian biodiversity with special reference as a megadiversity nation.

**5.** What are hotspots of biodiversity ? Which are the hotspots found in India ? Discuss their salient features.

**6.** What are the major threats to biodiversity ?

**7.** What are the major causes of man-wildlife conflicts ? Discuss the remedial steps that can curb the conflict.

**8.** What is Red Data Book ? What do you mean by extinct, endangered, vulnerable and rare species ? Name some endangered species of plants and animals of our country.

**9.** What is meant by *in situ* and *ex-situ* conservation of biodiversity ? Give examples.

**10.** Enumerate five important biosphere reserves, national parks (with important wild life) and wild life sanctuaries (with major wild life) of India. Also mention the state where they are located.

**11.** What do NBPGR and NBAGR stand for ? Where are they located ?

**12.** (*a*) Name the types of plants for which gene sanctuaries in India exist.

(*b*) Name the animals for whose protection and conservations specific projects have been launched in our country.

Unit

# 5 Environmental Pollution

For normal and healthy living a conducive environment is required by all the living beings, including humans, livestock, plants, micro-organisms and the wildlife. The favourable unpolluted environment has a specific composition. When this composition gets changed by addition of harmful substances, the environment is called polluted environment and the substances polluting it are called pollutants. **Environmental pollution can, therefore, be defined as any undesirable change in the physical, chemical or biological characteristics of any component of the environment (air, water, soil), which can cause harmful effects on various forms of life or property.** Environmental pollution could be of various types:

## ■ AIR POLLUTION

It is an atmospheric condition in which certain substances (including the normal constituents in excess) are present in concentrations which can cause undesirable effects on man and his environment. These substances include gases, particulate matter, radioactive substances etc.

Gaseous pollutants include oxides of sulphur (mostly $SO_2$, $SO_3$) oxides of nitrogen (mostly NO and $NO_2$ or $NO_x$), carbon monoxide (CO), volatile organic compounds (mostly hydrocarbons) etc. Particulate pollutants include smoke, dust, soot, fumes, aerosols, liquid droplets, pollen grains etc.

Radioactive pollutants include radon-222, iodine-131, strontium-90, plutonium-239 etc.

### Sources of Air Pollution

The sources of air pollution are natural and man-made (anthropogenic).

**Natural Sources:** The natural sources of air pollution are volcanic eruptions, forest fires, sea salt sprays, biological decay, photochemical oxidation of terpenes, marshes, extra terrestrial bodies, pollen grains of flowers, spores etc. Radioactive minerals present in the earth crust are the sources of radioactivity in the atmosphere.

**Man-made:** Man made sources include thermal power plants, industrial units, vehicular emissions, fossil fuel burning, agricultural activities etc. Thermal power plants have become the major sources for generating electricity in India as the nuclear power plants couldn't be installed as planned. The main pollutants emitted are fly ash and $SO_2$. Metallurgical plants also consume coal and produce similar pollutants. Fertilizer plants, smelters, textile mills, tanneries, refineries, chemical industries, paper and pulp mills are other sources of air pollution.

Automobile exhaust is another major source of air pollution. Automobiles release gases such as carbon monoxide (about 77%), oxides of nitrogen (about 8%) and hydrocarbons (about 14%). Heavy duty diesel vehicles spew more NOx and suspended particulate matter (SPM) than petrol vehicles which produce more carbon monoxide and hydrocarbons.

### Indoor Air Pollution

The most important indoor air pollutant is radon gas. Radon gas and its radioactive daughters are responsible for a large number of lung cancer deaths each year. Radon can be emitted from building materials like bricks, concrete, tiles etc. which are derived from soil containing radium. Radon is also present in groundwater and natural gas and is emitted indoors while using them.

Many houses in the under-developed and developing countries including India use fuels like coal, dung-cakes, wood and kerosene in their kitchens. Complete combustion of fuel produces carbon dioxide which may not be toxic. However, incomplete combustion produces the toxic gas carbon monoxide. Coal contains varying amounts of sulphur which on burning produces sulphur dioxide. Fossil fuel burning produces black soot. These pollutants i.e. CO, $SO_2$, soot and many others like formaldehyde, benzo- (a) pyrene (BAP) are toxic and harmful for health. BAP is also found in cigarette smoke and is considered to cause cancer. A house wife using wood as fuel for cooking inhales BAP equivalent to 20 packets of cigarette a day.

**Effects of air pollution:** Air pollution has adverse effects on living organisms and materials.

**Effects on Human Health:** Human respiratory system has a number of mechanisms for protection from air pollution. Bigger particles (> 10 μm) can be trapped by the hairs and sticky mucus in the lining of the nose. Smaller particles can reach tracheobronchial system and there get trapped in mucus. They are sent back to throat by beating of hair like cilia from where they can be removed by spitting or

swallowing. Years of exposure to air pollutants (including cigarette smoke) adversely affect these natural defenses and can result in lung cancer, asthma, chronic bronchitis and emphysema (damage to air sacs leading to loss of lung elasticity and acute shortness of breath). Suspended particulates can cause damage to lung tissues and diseases like asthma, bronchitis and cancer especially when they bring with them cancer causing or toxic pollutants attached on their surface. Sulphur dioxide ($SO_2$) causes constriction of respiratory passage and can cause bronchitis like conditions. In the presence of suspended particulates, $SO_2$ can form acid sulphate particles, which can go deep into the lungs and affect them severely.

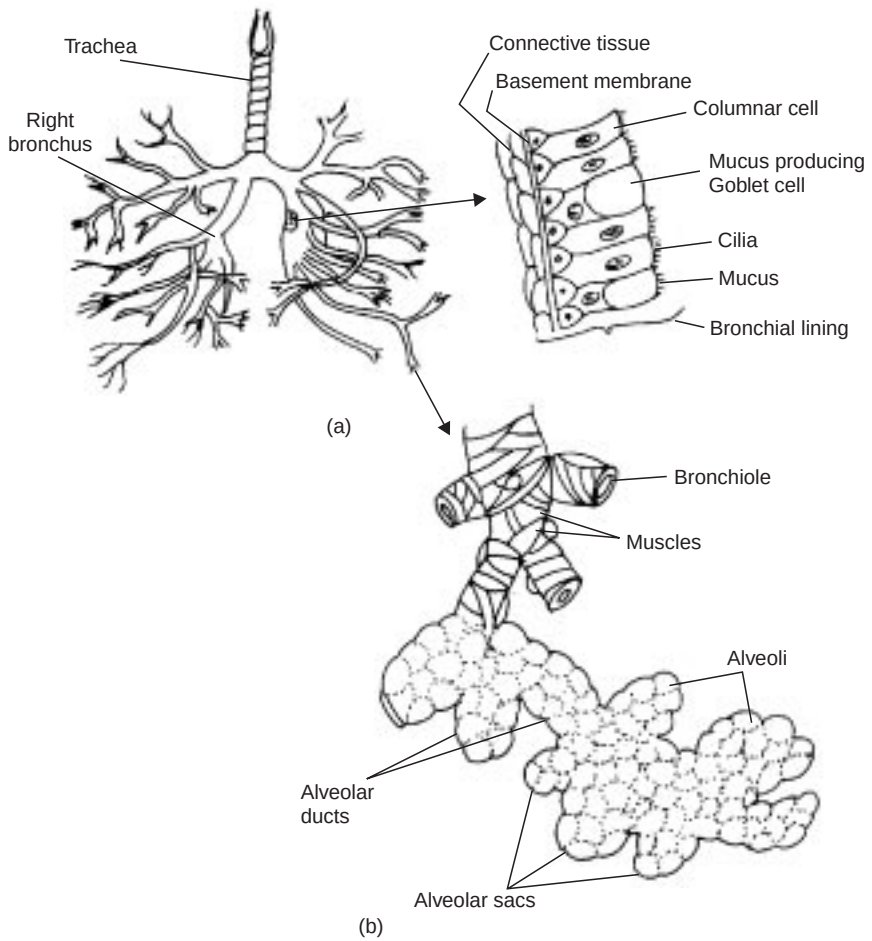



Fig. 5.1. Lower respiratory system of human beings (*a* and *b*) and cross section of bronchial lining showing cilia and goblet cells.

Oxides of nitrogen especially $NO_2$ can irritate the lungs and cause conditions like chronic bronchitis and emphysema. Carbon monoxide (CO) reaches lungs and combines with haemoglobin of blood to form carboxyhaemoglobin. CO has affinity for haemoglobin 210 times more than oxygen. Haemoglobin is, therefore, unable to transport oxygen to various parts of the body. This causes suffocation. Long exposure to CO may cause dizziness, unconsciousness and even death.

Many other air pollutants like benzene (from unleaded petrol), formaldehyde and particulates like polychlorinated biphenyls (PCBs) toxic metals and dioxins (from burning of polythene) can cause mutations, reproductive problems or even cancer.

**Effects on Plants:** Air pollutants affect plants by entering through stomata (leaf pores through which gases diffuse), destroy chlorophyll and affect photosynthesis. Pollutants also erode waxy coating of the leaves called cuticle. Cuticle prevents excessive water loss and damage from diseases, pests, drought and frost. Damage to leaf structure causes ***necrosis*** (dead areas of leaf), ***chlorosis*** (loss or reduction of chlorophyll causing yellowing of leaf) or ***epinasty*** (downward curling of leaf), and ***abscission*** (dropping of leaves). Particulates deposited on leaves can form encrustations and plug the stomata. The damage can result in death of the plant.

**Effects on aquatic life:** Air pollutants mixing up with rain can cause high acidity (lower pH) in fresh water lakes. This affects aquatic life especially fish. Some of the freshwater lakes have experienced total fish death.

**Effects on materials:** Because of their corrosiveness, particulates can cause damage to exposed surfaces. Presence of $SO_2$ and moisture can accelerate corrosion of metallic surfaces. $SO_2$ can affect fabric, leather, paint, paper, marble and limestone. Ozone in the atmosphere can cause cracking of rubber. Oxides of nitrogen can also cause fading of cotton and rayon fibres.

### Control of Air Pollution

Air pollution can be minimized by the following methods:

- Siting of industries after proper Environmental Impact Assessment studies.
- Using low sulphur coal in industries
- Removing sulphur from coal (by washing or with the help of bacteria)
- Removing $NO_x$ during the combustion process.

- Removing particulate from stack exhaust gases by employing electrostatic precipitators, bag-house filters, cyclone separators, scrubbers etc.
- Vehicular pollution can be checked by regular tune-up of engines ; replacement of more polluting old vehicles; installing catalytic converters ; by engine modification to have fuel efficient (lean) mixtures to reduce CO and hydrocarbon emissions; and slow and cooler burning of fuels to reduce $NO_x$ emission (Honda Technology).
- Using mass transport system, bicycles etc.
- Shifting to less polluting fuels (hydrogen gas).
- Using non-conventional sources of energy.
- Using biological filters and bio-scrubbers.
- Planting more trees.

## ■ NOISE POLLUTION

We hear various types of sounds everyday. Sound is mechanical energy from a vibrating source. A type of sound may be pleasant to someone and at the same time unpleasant to others. The unpleasant and unwanted sound is called noise.

Sound can propagate through a medium like air, liquid or solid. Sound wave is a pressure perturbation in the medium through which sound travels. Sound pressure alternately causes compression and rarefaction. The number of compressions and rarefactions of the molecules of the medium (for example air) in a unit time is described as frequency. It is expressed in Hertz (Hz) and is equal to the number of cycles per second.

There is a wide range of sound pressures, which encounter human ear. Increase in sound pressure does not invoke linear response of human ear. A meaningful logarithmic scale has been devised. The noise measurements are expressed as Sound Pressure Level (SPL) which is logarithmic ratio of the sound pressure to a reference pressure. It is expressed as a dimensionless unit, decibel (dB). The international reference pressure of $2 \times 10^{-5}$ Pa is the average threshold of hearing for a healthy ear. Decibel scale is a measure of loudness. Noise can affect human ear because of its loudness and frequency (pitch).

The Central Pollution Control Board (CPCB) committee has recommended permissible noise levels for different locations as given in Table 5.1.

**Table 5.1 Noise standards recommended by CPCB committee**

| Area code | Category of Area | Noise level in dB (A) Leq | |
|---|---|---|---|
| | | Day | Night |
| (A) | Industrial | 75 | 70 |
| (B) | Commercial | 65 | 55 |
| (C) | Residential | 55 | 45 |
| (D) | Silence Zone | 50 | 40 |

**Table 5.2. Different sounds and their sound levels on decibel scale**

| | Sound Level (dB) | | Source of Sound |
|---|---|---|---|
| | 180 | — | Rocket engine |
| | 170 | | |
| | 160 | | |
| | 150 | — | Jet plane take off |
| Threshold of Pain — | 140 | | |
| | 130 | — | Maximum recorded rock music |
| | 120 | — | Thunder cap |
| | 110 | — | Autohorn 1m away |
| | 100 | — | Jet fly over at 300 m, construction work, Newspaper press |
| | 90 | — | Motor cycle/8 m away, food blender |
| | 80 | | |
| | 70 | — | Vacuum cleaner, ordinary conversation |
| | 60 | — | Air conditioning unit, 6m away, light traffic noise, 30m away |
| | 50 | — | Average living room |
| | 40 | | |
| | 30 | — | Library, soft whisper |
| | 20 | — | Broadcasting studio |
| | 10 | — | Rustling leaf |
| Threshold of hearing — | 0 | | |

**Sources of Noise Pollution:** The main sources of noise are various modes of transportation (like air, road, rail-transportation), industrial operations, construction activities and celebrations (social/religious functions, elections etc) electric home appliances.

High levels of noise have been recorded in some of the cities of the world. In Nanjing (China) noise level of 105 dB has been recorded, while in some other cities of the world these levels are: Rome 90 dB, New York 88 dB, Calcutta 85 dB, Mumbai 82 dB, Delhi 80 dB, Kathmandu 75 dB.

**Effects of Noise:** Noise causes the following effects.

(*i*) **Interferes with man's communication:** In a noisy area communication is severely affected.

(*ii*) **Hearing damage:** Noise can cause temporary or permanent hearing loss. It depends on intensity and duration of sound level. Auditory sensitivity is reduced with noise level of over 90 dB in the midhigh frequency for more than a few minutes.

(*iii*) **Physiological and Psychological changes:** Continuous exposure to noise affects the functioning of various systems of the body. It may result in hypertension, insomnia (sleeplessness), gastro-intestinal and digestive disorders, peptic ulcers, blood pressure changes, behavioural changes, emotional changes etc.

## NOISE POLLUTION DURING DIWALI

Diwali is a festival of lights. Traditionally people of all ages enjoy firecrackers. Some accidents do occur every year claiming a few lives. Besides, noise generated by various firecrackers is beyond the permissible noise levels of 125 decibels as per the Environmental (Protection) (Second Amendment) Rules, 1999.

There has been a great concern over the noise levels generated during Diwali. Some measurements by certain group of researchers have also been made at various places during Diwali. It is recommended that the manufacturers of fireworks should mention the noise levels in decibels generated by individual items. The department of explosives of the Union Ministry of Commerce and Industry is entrusted with the task to ensure that the industry produces firecrackers conforming to permissible noise standards.

According to a recent test report on firecrackers produced by the National Physical Laboratory, New Delhi most of the firecrackers available in the market produce noise beyond the permissible levels of 125 decibels as per the Environment (Protection) (Second amendment) Rules, 1999. Some of them have been observed to produce noise near the threshold of pain. The details are given in Table 5.3.

**Table 5.3. Noise levels generated by firecrackers**

| Type of firecracker | Manufacturer | Generated noise level in decibels |
|---|---|---|
| Atom bomb (timing bomb) | Coronation Fireworks, Sivakasi | 135 ± 2 |
| Chinese crackers (a string of 1,000 in one piece) | Sri Kaliswari Fireworks, Sivakasi | 128 |
| Chinese crackers (a string of 600 in one piece) | Sri Kaliswari Fireworks, Sivakasi | 132 |
| Nazi (atom bomb) | Coronation Fireworks, Sivakasi | 135 ± 0 |
| Magic formula (flower bomb) | Rajan Fireworks, Sivakasi | 136 ± 1 |
| Atom bomb (foiled) | Sri Kailswari Fireworks, Sivakasi | 131 ± 2 |
| Hydrogen bomb | Sri Patrakali Fireworks, Sivakasi | 134 ± 2 |
| Rajan classic dhamaka (foiled bomb) | Rajan Fireworks, Sivakasi | 136 ± 0 |
| Samrat classic bomb (deluxe) | Venkateswara Fireworks, Sivakasi | 136 ± 0 |
| Hydro foiled (bomb) | Sri Kaliswari Fireworks, Sivakasi | 132 ± 2 |
| *Three sound (bomb) | Coronation Fireworks, Sivakasi | 119 ± 7 |
| Atom bomb | Local | 136 ± 0 |

*Cracker meeting the noise pollution standards.

*Source:* Test report on firecrackers, National Physical Laboratory, New Delhi, April 21, 2003

The noise levels were measured under standard conditions i.e. in areas not having noise-reflecting surfaces within a 15 metre radius. Two gadgets, for measuring sound levels were installed at a height of 1.3 metres and at a distance of 4 metres from the source of sound.

Besides mentioning the sound levels on each of the types of firecrackers or banning the production of such firecrackers which produce noise above permissible levels, it is important to educate people about the harmful effects of noise during such festivals like Diwali. It

can be done by giving public notices in the leading newspapers and messages through other mass media like radio and television.

Honourable Supreme Court in a Writ Petition (civil) of 1998 concerning noise pollution had passed the following directions as an interim measure.

The Union Government, The Union Territories as well as all the State Governments shall in particular comply with amended Rule 89 of the Environmental (Protection) Rules, 1986 framed under the Environmental (Protection) Act, 1986 which essentially reads as follows.

1. (*i*) The manufacture, sale or use of fire-crackers generating noise level exceeding 125 dB (AI) or 145 dB (C) pk at 4 meters distance from the point of bursting shall be prohibited.

   (*ii*) For individual fire-cracker constituting the series (joined fire-crackers), the above mentioned limit be reduced by 5 log 10 (N) dB, where N = Number of crackers joined together.

2. The use of fire works or fire crackers shall not be permitted except between 6.00 p.m. and 10.00 p.m. No fire works or fire crackers shall be used between 10.00 p.m. and 6.00 a.m.
3. Fire crackers shall not be used at any time in silence zones, as defined by the Ministry of Environment and Forests. Silence Zone has been defined as:

   ''Silence Zone in an area comprising not less that 100 meters around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority.
4. The State Education Resource Centres in all the States and Union Territories as well as the management/principals of schools in all the States and Union Territories shall take appropriate steps to educate students about the ill effects of air and noise pollution and apprise them of directions (1) to (3) above.

## Control of Noise Pollution

1. *Reduction in sources of noise:* Sources of noise pollution like heavy vehicles and old vehicles may not be allowed to ply in the populated areas.

2. Noise making machines should be kept in containers with sound absorbing media. The noise path will be in interrupted and will not reach the workers.
3. Proper oiling will reduce the noise from the machinery.
4. *Use of sound absorbing silencers:* Silencers can reduce noise by absorbing sound. For this purpose various types of fibrous material could be used.
5. Planting more trees having broad leaves.
6. *Through Law:* Legislation can ensure that sound production is minimized at various social functions. Unnecessary horn blowing should be restricted especially in vehicle-congested areas.

## ■ WATER POLLUTION

Water pollution can be defined as alteration in physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state.

**Sources of water pollution:** Water is an essential commodity for survival. We need water for drinking, cooking, bathing, washing, irrigation, and for industrial operations. Most of water for such uses comes from rivers, lakes or groundwater sources. Water has the property to dissolve many substances in it, therefore, it can easily get polluted. Pollution of water can be caused by point sources or non-point sources. Point sources are specific sites near water which directly discharge effluents into them. Major point sources of water pollution are industries, power plants, underground coal mines, offshore oil wells etc. The discharge from non-point sources is not at any particular site, rather, these sources are scattered, which individually or collectively pollute water. Surface run-off from agricultural fields, overflowing small drains, rain water sweeping roads and fields, atmospheric deposition etc. are the non-point sources of water pollution.

**Ground water pollution:** Ground water forms about 6.2% of the total water available on planet earth and is about 30 times more than surface water (streams, lakes and estuaries). Ground water seems to be less prone to pollution as the soil mantle through which water passes helps to retain various contaminants due to its cation exchange capacity. However, there are a number of potential sources of ground water pollution. Septic tanks, industry (textile, chemical, tanneries), deep well

injection, mining etc. are mainly responsible for ground water pollution, which is irreversible. Ground water pollution with arsenic, fluoride and nitrate are posing serious health hazards.

**Surface water pollution:** The major sources of surface water pollution are:

1. **Sewage:** Pouring the drains and sewers in fresh water bodies causes water pollution. The problem is severe in cities.
2. **Industrial effluents:** Industrial wastes containing toxic chemicals, acids, alkalis, metallic salts, phenols, cyanides, ammonia, radioactive substances, etc. are sources of water pollution. They also cause thermal (heat) pollution of water.
3. **Synthetic detergents:** Synthetic detergents used in washing and cleaning produce foam and pollute water.
4. **Agrochemicals:** Agrochemicals like fertilizers (containing nitrates and phosphates) and pesticides (insecticides, fungicides, herbicides etc.) washed by rain-water and surface run-off pollute water.
5. **Oil:** Oil spillage into sea-water during drilling and shipment pollute it.
6. **Waste heat:** Waste heat from industrial discharges increases the temperature of water bodies and affects distribution and survival of sensitive species.

### Effects of Water Pollution

Following are some important effects of various types of water pollutants:

**Oxygen demanding wastes:** Organic matter which reaches water bodies is decomposed by micro-organisms present in water. For this degradation oxygen dissolved in water is consumed. Dissolved oxygen (DO) is the amount of oxygen dissolved in a given quantity of water at a particular temperature and atmospheric pressure. Amount of dissolved oxygen depends on aeration, photosynthetic activity in water, respiration of animals and plants and ambient temperature.

The saturation value of DO varies from 8-15 mg/L. For active fish species (trout and Salmon) 5-8 mg/L of DO is required whereas less desirable species like carp can survive at 3.0 mg/L of DO.

Lower DO may be harmful to animals especially fish population. Oxygen depletion (deoxygenation) helps in release of phosphates from bottom sediments and causes eutrophication.

**Nitrogen and Phosphorus Compounds (Nutrients):** Addition of compounds containing nitrogen and phosphorus helps in the growth of algae and other plants which when die and decay consume oxygen of water. Under anaerobic conditions foul smelling gases are produced. Excess growth or decomposition of plant material will change the concentration of $CO_2$ which will further change pH of water. Changes in pH, oxygen and temperature will change many physico-chemical characteristics of water.

**Pathogens:** Many wastewaters especially sewage contain many pathogenic (disease causing) and non-pathogenic micro-organisms and many viruses. Water borne diseases like cholera, dysentery, typhoid, jaundice etc. are spread by water contaminated with sewage.

**Toxic Compounds:** Pollutants such as heavy metals, pesticides, cyanides and many other organic and inorganic compounds are harmful to aquatic organisms.

The demand of DO increases with addition of biodegradable organic matter which is expressed as biological oxygen demand (BOD). BOD is defined as the amount of DO required to aerobically decompose biodegradable organic matter of a given volume of water over a period of 5 days at 20°C. More BOD values of any water sample are associated with poor water quality. The non-biodegradable toxic compounds biomagnify in the food chain and cause toxic effects at various levels of food chain.

Some of these substances like pesticides, methyl mercury etc. move into the bodies of organisms from the medium in which these organisms live. Substances like DDT are not water soluble and have affinity for body lipids. These substances tend to accumulate in the organism's body. This process is called **bioaccumulation.** The concentration of these toxic substances builds up at successive levels of food chain. This process is called **biomagnification.** Following is the example of biomagnification of DDT in aquatic food chain:

| **Component** | **DDT concentration (ppm)** |
|---|---|
| Birds | 10.00 |
| ↑ | ↑ |
| Needle fish | 1.0 |
| ↑ | ↑ |
| Minnows | 0.1 |
| ↑ | ↑ |
| Zooplankton | 0.01 |
| ↑ | ↑ |
| Water | 0.000001 |

Toxic substances polluting the water ultimately affect human health. Some heavy metals like lead, mercury and cadmium cause various types of diseases. Mercury dumped into water is transformed into water soluble methyl mercury by bacterial action. Methyl mercury accumulates in fish. In 1953, people in Japan suffered from numbness of body parts, vision and hearing problems and abnormal mental behaviour. This disease called **Minamata disease** occurred due to consumption of methyl mercury contaminated fish caught from Minamata bay in Japan. The disease claimed 50 lives and permanently paralysed over 700 persons. Pollution by another heavy metal cadmium had caused the disease called **Itai-itai** in the people of Japan. The disease was caused by cadmium contaminated rice. The rice fields were irrigated with effluents of zinc smelters and drainage water from mines. In this disease bones, liver, kidney, lungs, pancreas and thyroid are affected.

Arsenic pollution of ground water in Bangladesh and West Bengal is causing various types of abnormalities.

Nitrate when present in excess in drinking water causes **blue baby syndrome** or **methaemoglobinemia**. The disease develops when a part of haemoglobin is converted into non-functional oxidized form.

Nitrate in stomach partly gets changed into nitrites which can produce cancer-causing products in the stomach.

Excess of fluoride in drinking water causes defects in teeth and bones called **fluorosis.**

Pesticides in drinking water ultimately reach humans and are known to cause various health problems. DDT, aldrin, dieldrin etc. have therefore, been banned. Recently, in Andhra Pradesh, people suffered from various abnormalities due to consumption of endosulphan contaminated cashew nuts.

### Control of Water Pollution

It is easy to reduce water pollution from point sources by legislation. However, due to absence of defined strategies it becomes difficult to prevent water pollution from non-point sources. The following points may help in reducing water pollution from non-point sources.

(*i*) Judicious use of agrochemicals like pesticides and fertilizers which will reduce their surface run-off and leaching. Avoid use of these on sloped lands.

(*ii*) Use of nitrogen fixing plants to supplement the use of fertilizers.

(*iii*) Adopting integrated pest management to reduce reliance on pesticides.

(*iv*) Prevent run-off of manure. Divert such run-off to basin for settlement. The nutrient rich water can be used as fertilizer in the fields.

(*v*) Separate drainage of sewage and rain water should be provided to prevent overflow of sewage with rainwater.

(*vi*) Planting trees would reduce pollution by sediments and will also prevent soil erosion.

For controlling water pollution from point sources, treatment of wastewaters is essential before being discharged. Parameters which are considered for reduction in such water are-

Total solids, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates and phosphates, oil and grease, toxic metals etc.

Wastewaters should be properly treated by primary and secondary treatments to reduce the BOD, COD levels upto the permissible levels for discharge.

Advanced treatment for removal of nitrates and phosphates will prevent eutrophication. Before the discharge of wastewater, it should be disinfected to kill the disease-causing organisms like bacteria.

Proper chlorination should be done to prevent the formation of chlorinated hydrocarbons or disinfection should be done by ozone or ultraviolet radiations.

## ■ THERMAL POLLUTION

Thermal pollution can be defined as presence of waste heat in the water which can cause undesirable changes in the natural environment.

**Causes of thermal pollution:** Heat producing industries i.e., thermal power plants, nuclear power plants, refineries, steel mills etc. are the major sources of thermal pollution. Power plants utilize only 1/3 of the energy provided by fossil fuels for their operations. Remaining 2/3 is generally lost in the form of heat to the water used for cooling. Cold water, generally, is drawn from some nearby water-body, passed through the plant and returned to the same water body, with temperature 10-16°C higher than the initial temperature. Excess of heat reaching such water bodies causes thermal pollution of water.

### Effects of Thermal Pollution

(*i*) The dissolved oxygen content of water is decreased as the solubility of oxygen in water is decreased at high temperature.

(*ii*) High temperature becomes a barrier for oxygen penetration into deep cold waters.

(*iii*) Toxicity of pesticides, detergents and chemicals in the effluents increases with increase in temperature.

(*iv*) The composition of flora and fauna changes because the species sensitive to increased temperature due to thermal shock will be replaced by temperature tolerant species.

(*v*) Metabolic activities of aquatic organisms increase at high temperature and require more oxygen, whereas oxygen level falls under thermal pollution.

(*vi*) Discharge of heated water near the shores can disturb spawning and can even kill young fishes.

(*vii*) Fish migration is affected due to formation of various thermal zones.

**Control of Thermal Pollution:**

The following methods can be employed for control of thermal pollution:

(*i*) Cooling ponds, (*ii*) Spray Ponds,

(*iii*) Cooling towers

(*i*) **Cooling Ponds:** Water from condensers is stored in ponds where natural evaporation cools the water which can then be recirculated or discharged in nearby water body. (Fig. 5.2)

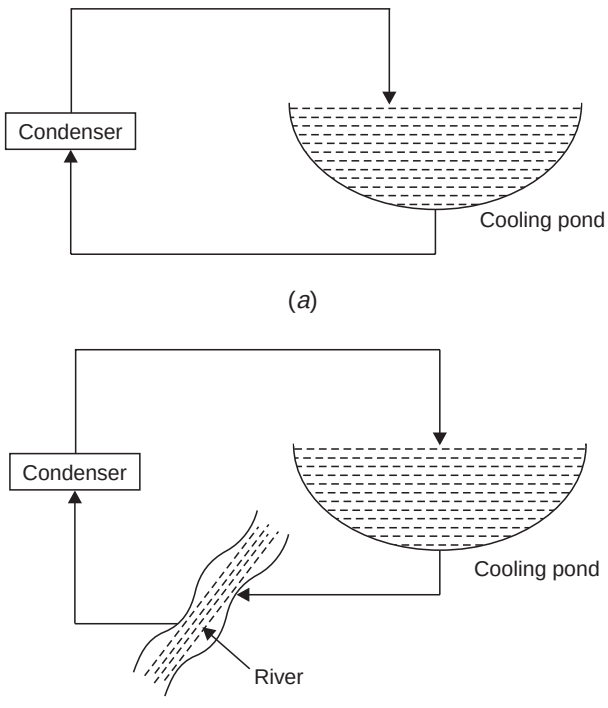



Fig. 5.2. Dissipation of heat by cooling ponds.

(*ii*) **Spray Ponds:** The water from condensers is received in spray ponds. Here the water is sprayed through nozzles where fine droplets are formed. Heat from these fine droplets is dissipated to the atmosphere. (Fig. 5.3)

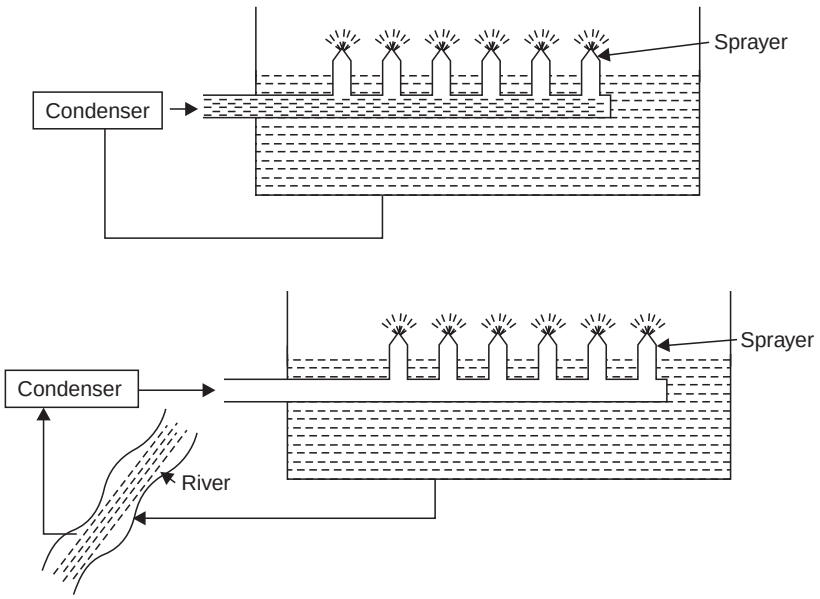



Fig. 5.3. Dissipation of heat by spray ponds.

(*iii*) **Cooling Towers:**

(*a*) *Wet cooling tower:* Hot water is sprayed over baffles. Cool air entering from sides takes away the heat and cools the water. This cool water can be recycled or discharged. Large amount of water is lost through evaporation and in the vicinity of wet cooling tower extensive fog is formed which is not good for environment and causes damage to vegetation. (Fig. 5.4)

(*b*) *Dry cooling tower:* The heated water flows in a system of pipes. Air is passed over these hot pipes with fans. There is no water loss in this method but installation and operation cost of dry cooling tower is many times higher than wet cooling tower.

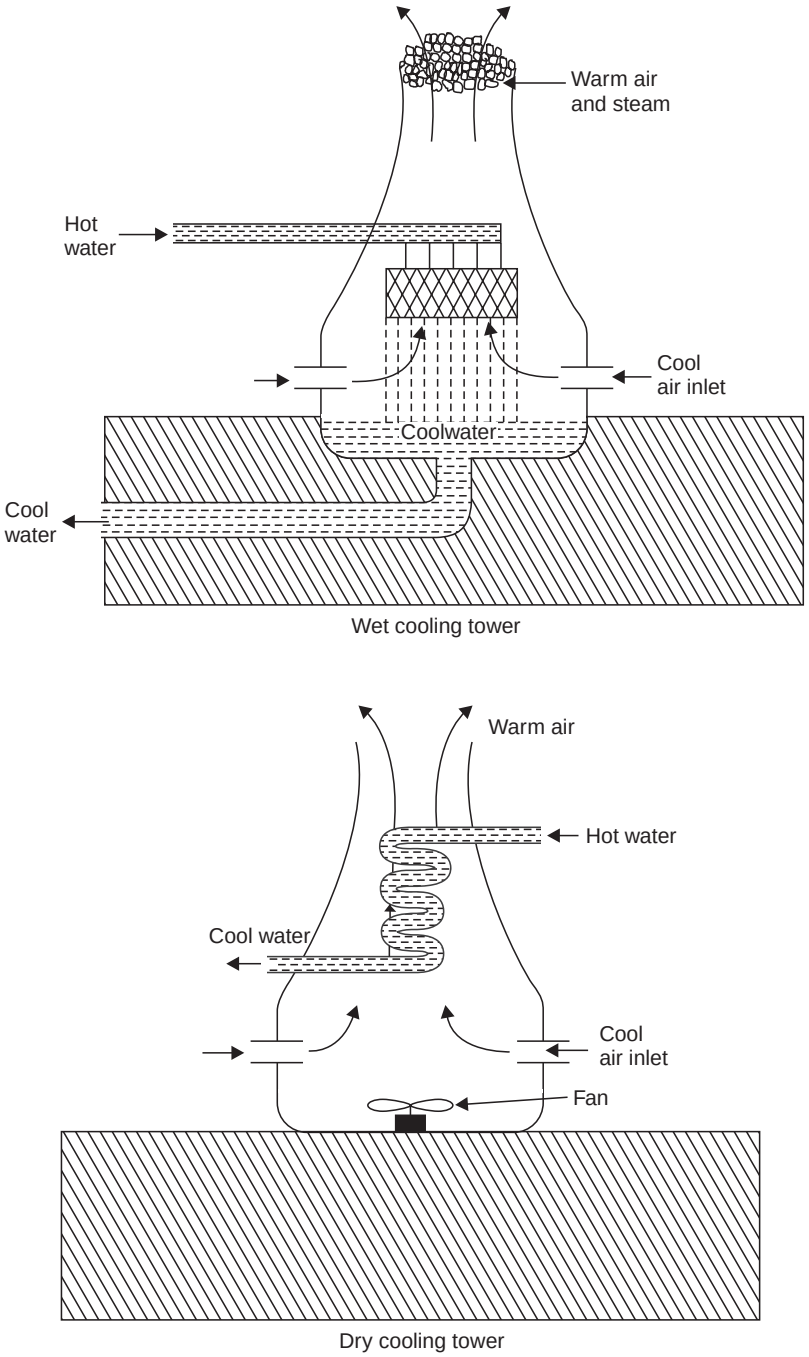



Fig. 5.4. Cooling towers: Wet and dry.

## ■ MARINE POLLUTION

The main sources of marine pollution are (*i*) rivers, which bring pollutants from their drainage basins, (*ii*) Catchment area i.e. coastline where human settlements in the form of hotels, industry, agricultural practices have been established, and (*iii*) oil drilling and shipment.

Most of the rivers ultimately join the ocean. The pollutants which these rivers carry from their drainage basins are finally poured into the sea. These include sewage sludge, industrial effluents, synthetic detergents, agrochemicals, solid wastes, plastics, metals and waste heat released by industries as discussed earlier.

In the sea the pollutants get diluted and the organic matter is further broken down as in river water. Still many pollutants specially the recalcitrant ones remain unchanged or are partially degraded causing marine pollution. These pollutants get biomagnified and affect fisheries and other marine life. Another important source of marine pollution is the leaking toxic substances, radioactive wastes etc. which are stored in large containers and dumped in deep sea considering sea to be a better disposal site than land.

Tankers and other shipping means, industries (petroleum, refinery, lubricating oil using industry, metal industry, paint industry), automotive wastes, refineries, ship-accidents and off shore production add to marine pollution. Tankers transporting oil contribute to oil pollution significantly. After delivering the oil through sea-route, earlier empty tankers used to be filled with water called ballast-water to maintain balance. The ballast-water containing residual oil from tankers was released into the sea on completion of return journey. Now-a-days the oil floating on the ballast water is removed in the newly designed 'load-on-top-tankers' before ballast-water is let-off.

Oil in sea water can spread over a large area of the sea, remain dispersed or get adsorbed on sediments. It can cause adverse effects on marine life.

Oil in the sea water affects sensitive flora and fauna. Phytoplankton, zooplankton, algal species, various species of invertebrates, coral reefs, fish, birds and mammals are affected by oil pollution. Fishes show mortality (death) because the fish gills get laden with oil after the slimy mucus of gills is affected. Oil disrupts the insulating capacity of feathers. Death occurs due to loss of buoyancy and subsequent drowning of birds. Leakage from oil tanker near Alaska in 1989 caused damage to coral reefs and resulted in death of about 390 thousand birds. Some important incidents of bird mortality due to oil have been reported at Brittany, France where 20 thousand birds

died due to more than 220 tonnes of oil spillage in 1978. At Elbe, Germany 500 thousand birds died in 1955. During the 1991 Gulf War 200 million gallons of oil spread in the Persian Gulf badly affected the marine ecosystem.

### Control of Marine Pollution

(*i*) Toxic pollutants from industries and sewage treatment plants should not be discharged in coastal waters.

(*ii*) Run off from non-point sources should be prevented to reach coastal areas.

(*iii*) Sewer overflows should be prevented by having separate sewer and rain water pipes.

(*iv*) Dumping of toxic, hazardous wastes and sewage sludge should be banned.

(*v*) Developmental activities on coastal areas should be minimized.

(*vi*) Oil and grease from service stations should be processed for reuse.

(*vii*) Oil ballast should not be dumped into sea.

(*viii*) Ecologically sensitive coastal areas should be protected by not allowing drilling.

## ■ SOIL POLLUTION

Soil is the upper layer of the earth crust which is formed by weathering of rocks. Organic matter in the soil makes it suitable for living organisms. Dumping of various types of materials especially domestic and industrial wastes causes soil pollution. Domestic wastes include garbage, rubbish material like glass, plastics, metallic cans, paper, fibres, cloth rags, containers, paints, varnishes etc. Leachates from dumping sites and sewage tanks are harmful and toxic, which pollute the soil.

Industrial wastes are the effluents discharged from chemical industries, paper and pulp mills, tanneries, textile mills, steel industries, distilleries, refineries, pesticides and fertilizer industries, pharmaceutical industries, food processing industries, cement industries, thermal and nuclear power plants, mining industries etc. Thermal power plants generate a large quantity of 'Fly ash'. Huge quantities of these wastes are dumped on soils, thus contaminating them.

Pesticides are used to kill pests that damage crops. These pesticides ultimately reach the soil and persist there for a long time. Pesticides which are persistent in nature are chlorinated hydrocarbon insecticides

e.g. DDT, HCH, endrin, lindane, heptachlor, endosulfan etc. Residues of these pesticides in the soils have long term effects especially under the temperate conditions.

Industrial wastes also contain some organic and inorganic compounds that are refractory and non-biodegradable. Industrial sludge may contain various salts, toxic substances, metals like mercury, lead, cadmium, arsenic etc. Agrochemicals released with the wastes of pesticide and fertilizer factories or during agricultural practices also reach the soil and pollute it.

Soil also receives excreta from animals and humans. The sewage sludge contains many pathogenic organisms, bacteria, viruses and intestinal worms which cause pollution in the soil.

The sources of radioactive substances in soil are explosion of radioactive devices, radioactive wastes discharged from industries and laboratories, aerial fall out etc. Isotopes of radium, uranium, thorium, strontium, iodine, caesium and of many other elements reach the soil and persist there for a long time and keep on emitting radiations.

### Effects of Soil Pollution

Sewage and industrial effluents which pollute the soil ultimately affect human health. Various types of chemicals like acids, alkalis, pesticides, insecticides, weedicides, fungicides, heavy metals etc. in the industrial discharges affect soil fertility by causing changes in physical, chemical and biological properties.

Some of the persistent toxic chemicals inhibit the non-target organisms, soil flora and fauna and reduce soil productivity. These chemicals accumulate in food chain and ultimately affect human health. Indiscriminate use of pesticides specially is a matter of concern.

Sewage sludge has many types of pathogenic bacteria, viruses and intestinal worms which may cause various types of diseases. Decomposing organic matter in soil also produces toxic vapours.

Radioactive fallout on vegetation is the source of radio-isotopes which enter the food chain in the grazing animals. Some of these radio isotopes replace essential elements in the body and cause abnormalities e.g. strontium-90 instead of calcium gets deposited in the bones and tissues. The bones become brittle and prone to fracture.

Radioisotopes which attach with the clay become a source of radiations in the environment.

Nitrogen and phosphorus from the fertilizers in soil reach nearby water bodies with agricultural run-off and cause eutrophication. Chemicals or their degradation products from soil may percolate and contaminate ground-water resources.

### Control of Soil Pollution

(*i*) Effluents should be properly treated before discharging them on the soil.

(*ii*) Solid wastes should be properly collected and disposed off by appropriate method.

(*iii*) From the wastes, recovery of useful products should be done.

(*iv*) Biodegradable organic waste should be used for generation of biogas.

(*v*) Cattle dung should be used for methane generation. Night-soil (human faeces) can also be used in the biogas plant to produce inflammable methane gas.

(*vi*) Microbial degradation of biodegradable substances is also one of the scientific approaches for reducing soil pollution.

## ■ NUCLEAR HAZARDS

Radioactive substances are present in nature. They undergo natural radioactive decay in which unstable isotopes spontaneously give out fast moving particles, high energy radiations or both, at a fixed rate until a new stable isotope is formed. (Fig. 2.5.7)

The isotopes release energy either in the form of gamma rays (high energy electromagnetic radiation) or ionization particles i.e. alpha particles and beta particles. The alpha particles are fast moving positively charged particles whereas beta particles are high speed negatively charged electrons. These ionization radiations have variable penetration power. (Fig. 5.5)

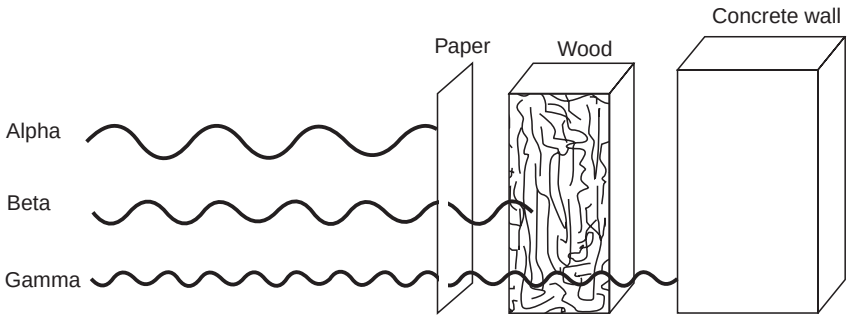



Fig. 5.5 Variable penetration power of ionisation radiations emitted by radioisotopes.

Alpha particles can be interrupted by a sheet of paper while beta particles can be blocked by a piece of wood or a few millimeters of aluminium sheet. The gamma rays can pass through paper and wood but can be stopped by concrete wall, lead slabs or water.

## Sources of Radioactivity

Various sources of radioactivity can be grouped into (*i*) Natural sources and (*ii*) Anthropogenic (man made) sources.

(*i*) **Natural Sources**: Sources of natural radioactivity include cosmic rays from outer space, radioactive radon-222, soil, rocks, air, water and food, which contain one or more radioactive substances.

(*ii*) **Anthropogenic sources**: These sources are nuclear power plants, nuclear accidents, X-rays, diagnostic kits, test laboratories etc. where radioactive substances are used.

## Effects of Radiations

Ionisation radiations can affect living organisms by causing harmful changes in the body cells and also changes at genetic level.

(*i*) **Genetic damage** is caused by radiations, which induce mutations in the DNA, thereby affecting genes and chromosomes. The damage is often seen in the offsprings and may be transmitted upto several generations.

(*ii*) **Somatic damage** includes burns, miscarriages, eye cataract and cancer of bone, thyroid, breast, lungs and skin.

Many scientists are of the view that due to the body's ability to repair some of the damages, the adverse effects of radiations are observed only beyond a threshold level. However, the other group believes that even a small dose of radiations over a period of time may cause adverse effects. They believe that the permissible limits of ionising radiations should be further reduced.

Damage caused by different types of radiations depends on the penetration power and the presence of the source inside or outside the body. Alpha particles lack penetration power but they have more energy than beta. They will be, therefore, dangerous when they enter the body by inhalation or through food. Alpha particles cannot penetrate the skin to reach internal organs whereas beta particles can damage the internal organs. Greater threat is posed by radioisotopes with intermediate half-lives as they have long time to find entry inside the human body.

Radioisotopes enter the environment during mining of uranium. The radioactivity in the earth's crust enters the crops grown there and ultimately in human beings. Radionuclides enter the water bodies or the groundwater coming in contact with the contaminated soil or rock.

Radioactive iodine ($I^{131}$) accumulates in thyroid gland and causes cancer. Similarly, strontium-90 accumulates in the bones and causes leukemia or cancer of bone marrow.

### Control of Nuclear Pollution

(*i*) Siting of nuclear power plants should be carefully done after studying long term and short term effects.

(*ii*) Proper disposal of wastes from laboratory involving the use of radioisotopes should be done.

## ■ SOLID WASTE MANAGEMENT

Higher standards of living of ever increasing population has resulted in an increase in the quantity and variety of waste generated. It is now realized that if waste generation continues indiscriminately then very soon it would be beyond rectification. Management of solid waste has, therefore, become very important in order to minimize the adverse effects of solid wastes. Solid waste (waste other than liquid or gaseous) can be classified as municipal, industrial, agricultural, medical, mining waste and sewage sludge.

### Sources of Urban and Industrial Wastes

Urban waste consists of medical waste from hospitals; municipal solid wastes from homes, offices, markets (commercial waste) small cottage units, and horticulture waste from parks, gardens, orchards etc.

- **Waste from homes (Domestic waste)** contains a variety of discarded materials like polyethylene bags, empty metal and aluminium cans, scrap metals, glass bottles, waste paper, diapers, cloth/rags, food waste etc.
- **Waste from shops** mainly consists of waste paper, packaging material, cans, bottles, polyethylene bags, peanut shells, eggshells, tea leaves etc.
- **Biomedical waste** includes anatomical wastes, pathological wastes, infectious wastes etc.
- **Construction/demolition waste** includes debris and rubbles, wood, concrete etc.
- **Horticulture waste and waste from slaughter houses** include vegetable parts, residues and remains of slaughtered animals, respectively.

The urban solid waste materials that can be degraded by micro-organisms are called **biodegradable wastes**. Examples of this type of waste are vegetable wastes, stale food, tea leaves, egg shells, peanut shells, dry leaves etc. Wastes that cannot be degraded by micro-organisms are called **non-biodegradable wastes**. For example, polyethylene bags, scrap metal, glass bottles etc.

- **Industrial waste:** Industrial waste consists of a large number of materials including factory rubbish, packaging material, organic wastes, acids, alkalis and metals etc. During some industrial processing large quantities of hazardous and toxic materials are also produced. The main sources of industrial wastes are chemical industries, metal and mineral processing industries. Radioactive wastes are generated by nuclear power plants. Thermal power plants produce fly ash in large quantities. Solid wastes from other types of industries include scrap metal, rubber, plastic, paper, glass, wood, oils, paints, asphalt, tars, dyes, scrap leather, ceramics, abrasives, slag, heavy metals, asbestos, batteries. In Europe and North America the environmental laws and safety laws are becoming more stringent due to which disposal of hazardous wastes is becoming a problem. Cost of disposal of such wastes is increasing. Therefore, these wastes are being exported to developing countries which do not even have sufficient knowledge or technique for their disposal.

### Effects of Solid Wastes

Municipal solid wastes heap up on the roads due to improper disposal system. People clean their own houses and litter their immediate surroundings which affects the community including themselves. This type of dumping allows biodegradable materials to decompose under uncontrolled and unhygienic conditions. This produces foul smell and breeds various types of insects and infectious organisms besides spoiling the aesthetics of the site.

Industrial solid wastes are sources of toxic metals and hazardous wastes, which may spread on land and can cause changes in physico-chemical and biological characteristics thereby affecting productivity of soils. Toxic substances may leach or percolate to contaminate the ground water.

In refuse mixing the hazardous wastes are mixed with garbage and other combustible waste. This makes segregation and disposal all the more difficult and risky. Various types of wastes like cans, pesticides, cleaning solvents, batteries (zinc, lead or mercury) radioactive materials, plastics are mixed up with paper, scraps and other non-toxic materials which could be recycled. Burning of some of these materials produce dioxins, furans and polychlorinated biphenyls, which have the potential to cause various types of ailments including cancer.

**Management of Solid Waste:** For waste management we stress on 'three R's'-Reduce, reuse and recycle before destruction and safe storage of wastes.

(*i*) **Reduction in use of raw materials:** Reduction in the use of raw materials will correspondingly decrease the production of waste. Reduced demand for any metallic product will decrease the mining of their metal and cause less production of waste.

(*ii*) **Reuse of waste materials:** The refillable containers which are discarded after use can be reused. Villagers make casseroles and silos from waste paper and other waste materials. Making rubber rings from the discarded cycle tubes which are used by the newspaper vendors, instead of rubber bands, reduces the waste generation during manufacturing of rubber bands. Because of financial constraints poor people reuse their materials to the maximum.

(*iii*) **Recycling of materials:** Recycling is the reprocessing of discarded materials into new useful products.

(*i*) Formation of some old type products e.g. old aluminium cans and glass bottles are melted and recast into new cans and bottles.

(*ii*) Formation of new products: Preparation of cellulose insulation from paper, preparation of fuel pellets from kitchen waste. Preparation of automobiles and construction materials from steel cans.

The process of reducing, reusing and recycling saves money, energy, raw materials, land space and also reduces pollution. Recycling of paper will reduce cutting of trees for making fresh paper. Reuse of metals will reduce mining and melting of ores for recovery of metals from ores and prevent pollution.

For **discarding wastes** the following methods can be adopted:

(*i*) **Sanitary landfill**: In a sanitary landfill, garbage is spread out in thin layers, compacted and covered with clay or plastic foam.

In the modern landfills the bottom is covered with an impermeable liner, usually several layers of clay, thick plastic and sand. The liner protects the ground water from being contaminated due to percolation of leachate. Leachate from bottom is pumped and sent for treatment. When landfill is full it is covered with clay, sand, gravel and top soil to prevent seepage of water. Several wells are drilled near the landfill site to monitor if any leakage is contaminating ground water. Methane produced by anaerobic decomposition is collected and burnt to produce electricity or heat.

(*ii*) **Composting**: Due to shortage of space for landfill in bigger cities, the biodegradable yard waste (kept separate from the municipal

waste) is allowed to degrade or decompose in an oxygen rich medium. A good quality nutrient rich and environmental friendly manure is formed which improves the soil conditions and fertility.

(*iii*) **Incineration**: Incinerators are burning plants capable of burning a large amount of materials at high temperature. The initial cost is very high. During incineration high levels of dioxins, furans, lead and cadmium may be emitted with the fly ash of incinerator. Dioxin level may reach many times more than in the ambient environment. For incineration of materials, it is better to remove batteries containing heavy metals and plastic containing chlorine before burning the material. Prior removal of plastics will reduce emissions of dioxins and polychlorinated biphenyls (PCBs)

## ■ ROLE OF AN INDIVIDUAL IN PREVENTION OF POLLUTION

The role of every individual in preventing pollution is of paramount importance because if every individual contributes substantially the effect will be visible not only at the community, city, state or national level but also at the global level as environment has no boundaries. It is the responsibility of the human race which has occupied the commanding position on this earth to protect the earth and provide conducive environment for itself and innumerable other species which evolved on this earth. A small effort made by each individual at his own place will have pronounced effect at the global level. It is aptly said, *"Think globally act locally"*.

Each individual should change his or her life style in such a way as to reduce environmental pollution. It can be done by following some of the following suggestions.

- Help more in pollution prevention than pollution control.
- Use ecofriendly products.
- Cut down the use of chlorofluorocarbons (CFCs) as they destroy the ozone layer. Do not use polystyrene cups that have chlorofluorocarbon (CFC) molecules in them which destroy ozone layer.
- Use the chemicals derived from peaches and plums to clean computer chips and circuit boards instead of CFCs.
- Use CFC free refrigerators.

The manufacture and operation of such devices should be encouraged that don't pollute. If they cost more then their higher prices may be offset by including environmental and the social costs of pollution in the price of such products which pollute environment.

Air pollution can be prevented by using really clean fuel i.e. hydrogen fuel. Hydrogen for that matter should not be produced by passing current in water as for generation of this current, again the environment will be polluted. So solar powered hydrogen fuel is the need of the hour.

- Reduce your dependency on fossil fuel especially coal or oil.
- Save electricity by not wasting it when not required because electricity saved is electricity generated without polluting the environment. Put on warm clothes rather than switching on a heater.
- Adopt and popularize renewable energy sources.
- Improve energy efficiency. This will reduce the amount of waste energy, i.e. more is achieved with less energy.
- Promote reuse and recycling wherever possible and reduce the production of wastes.
- Use mass transport system. For short-visits use bicycle or go on foot. Decrease the use of automobiles.
- Use pesticides only when absolutely necessary and that too in right amounts. Wherever possible integrated pest management, including alternate pest control methods (biological control), should be used.
- Use rechargeable batteries. Rechargeable batteries will reduce metal pollution.
- Use less hazardous chemicals wherever their application can be afforded. Baking soda, vinegar and borax can help in cleaning, bleaching and softening. Baking soda can replace modern deodorants.
- The solid waste generated during one manufacturing process can be used as a raw material for some other processes.
- Use low phosphate, phosphate-free or biodegradable dish washing liquid, laundry detergent and shampoo. This will reduce eutrophication of water bodies.
- Use organic manure instead of commercial inorganic fertilizers.
- Do not put pesticides, paints, solvents, oils or other harmful chemicals into the drain or ground water.
- Use only the minimum required amount of water for various activities. This will prevent fresh water from pollution.

- When building a home, save (don't cut) as many trees as possible in the area.
- Plant more trees, as trees can absorb many toxic gases and can purify the air by releasing oxygen
- Check population growth so that demand of materials is under control.

## ■ POLLUTION CASE STUDIES

**Air Pollution Episodes:** A series of air pollution disasters have occurred in the past 75 years from Meuse Valley, Belgium (1930) to Chernobyl nuclear disaster in, the erstwhile USSR (1986). Some of the important ones are given below:

**Donora air pollution disaster:** Donora of Pennsylvania (in USA) is a small mill town dominated by steel mill, zinc smelter and sulphuric acid plant. A four days fog occurred from October 25-31, 1948. Due to anticyclonic weather conditions there was no air movement and temperature inversion had set in due to sea breeze conditions. Donora lies in a horse shoe shaped valley on the Monongahela river, south of Pittsburgh with steep raising hills on each side of the river.

Fog which formed due to accumulation of cold air at the bottom of the river valley persisted for 4 consecutive days. This condition, when cold layer is trapped below the warm layer, is called **inversion**. The top fog layer reflected the solar radiations during the day time. So the heat received by it was not sufficient to break the inversion. During night times the top layer had been loosing heat which further cooled the layer to stabilize. Wind speed in the inversion layer was also slow. The deadly pollutants emitted by the steel mill, zinc smelter and sulphuric acid plant got trapped and concentrated in the stable weather conditions of the valley and remained there for four days. About 6000 of the town's 14,000 inhabitants fell ill and 20 of them died.

**The Bhopal Gas Tragedy:** The world's worst industrial accident occurred in Bhopal, M.P., India on the night of 2nd and morning of 3rd December, 1984. It happened at Union Carbide Company which used to manufacture Carbaryl (Carbamate) pesticide using Methyl isocyanate (MIC). Due to accidental entry of water in the tank, the reaction mixture got overheated and

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exploded because its cooling system had failed. Other safety devices also did not work or were not in the working condition. Forty tons of MIC leaked into the atmosphere which might have contained 40 kg of phosgene as an impurity. MIC gas at lower concentrations affects lungs and eyes and causes irritation in the skin. Higher amounts remove oxygen from the lungs and can cause death. In the winter night of December there were fog like clouds over south and east of the plant. The gas spread over 40 $Km^2$ area. About 5100 persons were killed (2600 due to direct exposure to MIC and other 2500 due to aftereffects of exposure) according to Indian officials. About 2,50,000 persons got exposed to MIC. An estimated 65,000 people suffered from severe eye, respiratory, neuromuscular, gastrointestinal and gynecological disorders. About 1000 persons became blind. Without counting the damage of human lives, it cost about $ 570 million in clean up and damage settlement. This tragedy could have been averted had the company spend about $ 1 million on safety improvement.

### The Love Canal Tragedy

The Love canal tragedy occurred in a suburb of Niagara Falls, New York. The love canal was built by William Love which was later dug up and was used to dump sealed steel drums of chemical wastes by Hooker Chemicals and Plastics Corporation between 1942-1953. In 1953, the dump site was covered with clay and topsoil by the company and was sold to the city Board of Education which built an elementary school on that site. Houses were also built near the school. In 1976, the residents started complaining of foul smell. Children playing in the canal area received chemical burns.

In 1977, the corroded steel containers started leaking the chemicals into storm sewers, basement of homes and the school playground. About 26 toxic organic compounds were identified. The dump site was covered with clay and the leaking wastes were pumped to new treatment plant. The affected families were relocated.

There could be many more dump sites similar to Love canal especially in the third world countries. Who knows what amount of harm such dump sites are causing to the underground aquifers?

**Arsenic pollution in groundwater:** West Bengal and Bangladesh are severely contaminated by the toxic heavy metal arsenic. The first report of arsenic pollution in West Bengal came in 1978 and that in Bangladesh in 1993, where it was found to be even more widespread. Arsenic poisoning has far reaching consequences. The local people were found to be ingesting low doses of arsenic for 10-14 years after which suddenly white or black spots called melanosis started mottling the skin. The spots were later found to get converted into leprosy like skin lesions encrusting the palms and soles, eventually rotting into gangrenous ulcers. Long exposures often led to bladder and lung cancer. Children are more badly affected by arsenicosis, the affected people are socially isolated, children barred from attending schools and young women remain single or have broken marriage. The WHO has prescribed the maximum permissible limits of arsenic as 10 mg/L. In West Bengal 40 million out of 90 million people are feared to have likely exposure to arsenic threat due to contaminated water. The 24 Paraganas, Hooghly and Murshidabad districts as also Behala and South Eastern fringes of Kolkata lie in Arsenic Risk Zone. Earlier it was postulated that the arsenic has entered into groundwater due to geologic reasons in the Ganga Delta. Recently, however, it is being linked with anthropogenic causes.

Excessive use of lead arsenate and copper arsenite as pesticides in high yielding varieties of summer paddy and jute crop seems to be the major cause of arsenic pollution. Now the arsenic contaminated tubewells in the state are being painted red while safe water tubewells are painted green for use by people.

**Chernobyl Nuclear Disaster**

Chernobyl nuclear accident is the worst nuclear disaster in the history of human civilization which occurred at Chernobyl, Ukraine in the erstwhile USSR (now CIS). On 26 April, 1986 the accident occurred at the reactor of the Chernobyl power plant designed to produce 1000 MW electrical energy. The reactor had been working continuously for 2 years. It was shut down on April 25, 1986 for intermediate repairs. This period coincided with the period when people including the top executives were busy in the preparations for national holiday, The May Day. Due to faulty operations of shutting down the plant, an explosion occurred in

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the reactor at 01.23 hrs on April 26, 1986. Three seconds later another explosion occurred.

The explosion was so severe that the 1000 tonne steel concrete lid of the reactor 4 blew off. Fire started at the reactor due to combustion of graphite rods. The reactor temperature soared to more than 2000°C. Fuel and radioactive debris spewed out in a volcanic cloud of molten mass of the core and gases. The debris and gases drifted over most of the northern hemisphere. Poland, Denmark, Sweden and Norway were affected.

On first day of the accident 31 persons died and 239 people were hospitalized. Since the plume was rich in Iodine-131, Cesium-134 and Cesium-137, it was feared that some of the 5,76,000 people exposed to the radiations would suffer from cancer specially thyroid cancer and leukemia. Children were more susceptible as Iodine-131 is ingested mainly through milk and milk products. Since children consume more milk and their thyroid glands are in the growing stage, an increase in thyroid cancer in children from areas near Chernobyl was registered. More than 2000 people died. People suffered from ulcerating skin, loss of hair, nausea and anemia.

Agricultural produce was damaged for years. Intense radiations destroyed several fields, trees, shrubs, plants etc. Flora and fauna were destroyed. Blood abnormalities, hemorrhagic diseases, changes in lungs, eye diseases, cataract, reproductive failure and cancer cases increased. Sweden and Denmark banned the import of contaminated Russian products.

The nuclear energy is cheap, inexhaustible and non-polluting source of energy. However, in the absence of proper care and caution, disasters like Chernobyl can rock the society.

**Pollution Problem Areas of India as Identified by CPCB**

| S. No. | Name | State/U.T. |
|---|---|---|
| 1. | Bhadravati | Karnataka |
| 2. | Chembur | Maharashtra |
| 3. | Digboi | Assam |
| 4. | Dhanbad | Bihar |
| 5. | Durgapur | W.B. |
| 6. | Govindgarh | Punjab |

*Contd.*

| | | |
|---|---|---|
| 7. | Greater Cochin | Kerala |
| 8. | Howrah | W.B. |
| 9. | Jodhpur | Rajasthan |
| 10. | Kala-Amb | H.P. |
| 11. | Korba | M.P. |
| 12. | Manali | T.N. |
| 13. | Nagda-Ratlam | M.P. |
| 14. | Najafgarh Drain Basin | Delhi |
| 15. | North Arcot | T.N. |
| 16. | Pali | Rajasthan |
| 17. | Parwanoo | H.P. |
| 18. | Patancheru-Bollaram | A.P. |
| 19. | Singrauli | U.P. |
| 20. | Talcher | Orissa |
| 21. | Vapi | Gujarat |
| 22. | Vishakhapatnam | A.P. |
| 23. | Tarapur | Maharashtra |
| 24. | Ankleshwar | Gujarat |

*Source :* Annual Report CPCB, 2002-2003.

## ■ DISASTER MANAGEMENT

Geological processes like earthquakes, volcanoes, floods and landslides are normal natural events which have resulted in the formation of the earth that we have today. They are, however, disastrous in their impacts when they affect human settlements. Human societies have witnessed a large number of such natural hazards in different parts of the world and have tried to learn to control these processes, to some extent.

**Earthquakes:** Earthquakes occur due to sudden movements of earth's crust. The earth's crust has several tectonic plates of solid rock which slowly move along their boundaries. When friction prevents these plates from slipping, stress builds up and results in sudden fractures which can occur along the boundaries of the plates or fault lines (planes of weakness) within the plates. This causes earthquakes, the violent, short-term vibrations in the earth. The point on a fault at which the first movement occurs during an earthquake is called the **epicenter**.

The severity of an earthquake is generally measured by its magnitude on Richter Scale, as shown below:

| *Richter Scale* | *Severity of earthquake* |
|---|---|
| Less than 4 | Insignificant |
| 4 - 4.9 | Minor |
| 5 - 5.9 | Damaging |
| 6 - 6.9 | Destructive |
| 7 - 7.9 | Major |
| More than 8 | Great |

The largest earthquake ever recorded occurred on May 22, 1960 in Chile with the estimated magnitude of 9.5 on Richter Scale, affecting 90,000 square miles and killing 6,000 people.

The devastating earthquake which hit Bhuj Town in Gujarat had caused massive damage, killing 20,000-30,000 people and leaving many injured. It had an energy equivalent to a 5.3 megaton hydrogen bomb.

Earthquake-generated water waves called **tsunamis** can severely affect coastal areas. These giant sea swells can move at a speed upto 1000 Km/hr or even faster. While approaching the sea shore they may often reach 15 m or sometimes upto 65 m in height and cause massive devastation in coastal areas. In China such waves killed 8,30,000 people in 1556 and 50,000 in 1976.

Anthropogenic activities can also cause or enhance the frequency of earthquakes. Three such activities identified are:

(*a*) Impoundment of huge quantities of water in the lake behind a big dam.

(*b*) Under ground nuclear testing.

(*c*) Deep well disposal of liquid waste.

Damage to property and life can be prevented by constructing earthquake-resistant buildings in the earthquake prone zones or seismic areas. For this, the structures are heavily reinforced, weak spots are strategically placed in the building that can absorb vibrations from the rest of the building, pads or floats are placed beneath the building on which it can shift harmlessly during ground motion. Wooden houses are preferred in earthquake prone areas as in Japan.

### Floods

Generally the stream channels accommodate some maximum stream flow. However, due to heavy rains or sudden snow melt the quantity of

water in streams exceeds their capacity and water overflows the banks and causes inundation of the surrounding land. This situation is called flood.

A flood generally doesn't damage property or cause casualities to an extent as done by other natural disasters. However, it causes a great economic loss and health related problems due to widespread contamination. Virtually anything the flood water touches gets contaminated, posing serious threat to health due to outbreak of epidemics.

Human activities have been the main causes for increasing the severity and frequency of floods. Construction of roads, parking space and buildings that cover the earth's surface hardly allows infiltration of water into the soil and speeds up the runoff. Clearing of forests for agriculture has also increased the severity of floods.

In India, Uttar Pradesh is considered to be amongst the worst flood hit states of the country. It has nearly 20% of the total 40 million hectares of flood prone zone of the country.

Flood plains, the low lying areas which get inundated during floods help to reduce floods. Building up of flood control structures like flood walls or deepening of river channels have only transferred the problems downstream. Building walls prevents spilling out the flood water over flood plains, but it increases the velocity of water to affect the areas downstream with greater force.

Table 5.4 shows the occurrence of natural hazards in our country. On an average, every year one major disaster hits India, causing huge economic losses and loss of human life. There is a need for systematic studies and strategies to evolve a Disaster Management Plan for our country.

To check the floods, efforts need to be made to restore wetlands, replace ground cover on water-courses, build check-dams on small streams, move buildings off the flood plains etc. Instead of raising buildings on flood plains, it is suggested that floodplains should be used for wildlife habitat, parks, recreational areas and other uses, which are not susceptible to flood damage. River-networking in the country is also being proposed to deal with the flood problem.

**Table 5.4. Frequently occurring natural disasters in India**

| Type | Location/Area | Affected Population (in Million) |
|---|---|---|
| Floods | 8 major river valleys spread over 40 million hectares of area in the entire country | 260 |
| Drought | Spread in 14 states of Andhra Pradesh, Bihar, Gujarat, Haryana, Jammu & Kashmir, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal and Himachal Pradesh covering a total of 116 districts and 740 blocks | 86 |
| Earthquake | Nearly 55% of the total area of the country falling in the seismic zone IV and V. | 400 |
| Cyclones | Entire 5700 km long coastline of Southern, Peninsular India covering 9 States viz. Gujarat, Maharastra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa and West Bengal and Union Territory of Pondicherry besides Islands of Lakshadweep and Andaman and Nicobar | 10 |
| Landslide | Entire sub Himalayan region and Western Ghats | 10 |

*Source:* State of Environment, 1995, Ministry of Environment and Forests, Government of India.

## Landslides

Landslide occurs when coherent rock of soil masses move downslope due to gravitational pull. Slow landslips don't cause much worry but sudden rockslides and mudslides are dangerous.

Water and vegetation influence landslides. Chemical action of water gradually cause chemical weathering of rocks making them prone to landslides. Vegetation consolidates the slope material, provides cohesion by its root system and also retards the flow of water and its erosion capacity.

However, this can be masked by many other exerting factors like:

(*i*) Earthquakes, vibrations etc.

(*ii*) Disturbances in resistant rock overlying rock of low resistance.

(*iii*) Saturation of the unconsolidated sediments with water.

(*iv*) Unconsolidated sediments exposed due to logging, road or house building.

Landslides are governed by the forces which tend to pull the earth material down slope (move in case of slopes with steeper slip plane) and resisting forces which tend to resist such movements.

It is difficult to control landslides. However, these can be minimized by stabilizing the slope by:

(*i*) Draining the surface and subsurface water.

(*ii*) Providing slope support like gabions (wired stone blocks)

(*iii*) Concrete support at the base of a slope.

### Cyclones

Cyclones are recurring phenomena in the tropical coastal regions. Tropical cyclones in the warm oceans are formed because of heat and moisture. One of the requirements for formation of tropical cyclones is that the sea surface temperature (SST) should be above 26°C. Tropical cyclones move like a spinning top at the speed of 10-30 Km per hour. They can last for a week or so and have a diameter varying between 100 to 1500 Km. Since in the western parts of the main ocean no cold currents exist, tropical cyclones originate there. Tropical cyclones are called **hurricanes** in the Atlantic, Caribbean and north eastern Pacific, '**typhoons'** in the western Pacific; and **'cyclones'** in the Indian Ocean and **'willy willies'** in the sea around Australia.

More storms occur in the Bay of Bengal than in the Arabian Sea. Of 5-6 storms that form in the year about half of them are severe. Hurricane winds (74 miles per hour or more), rains and storm surge (often 50-100 miles wide dome of water) often devastate the area where it strikes on land. The devastation is more when storm surge and normal astronomical tide coincide. Sea water with combined force rushes inlands and inundates the low lying areas.

**Management:** It is difficult to stop the recurrence of cyclones. Some long term defence measures can help to protect us from devastation. Such measures include, planting more trees on the coastal belt, construction of dams, dykes, embankments, storm shelter, wind breaks, proper drainage and wide roads for quick evacuation.

## QUESTIONS

1. Define pollution. Name various atmospheric pollutants.
2. What are the natural and man made pollutants that cause air pollution.

**3.** Give an account of indoor air pollution.
**4.** Give an account of the adverse effects of air pollution.
**5.** Enumerate various methods for control of air pollution.
**6.** Differentiate between
(*i*) Sound and noise
(*ii*) Loudness and pitch of noise
(*iii*) Threshold of pain and threshold of hearing for a human ear.
**7.** Briefly describe the sources, effects and control of noise pollution.
**8.** Give an account of noise generated during diwali. What would you suggest to reduce this menace ?
**9.** Enumerate with examples the major sources of surface water pollution and ground water pollution.
**10.** Write short notes on
(*a*) Minamata disease
(*b*) Biomagnification
(*c*) Itai-itai disease
(*d*) Blue baby syndrome
(*e*) B.O.D.
**11.** Discuss adverse effects and control of water pollution.
**12.** What do you understand by the term thermal pollution ? Discuss various effects and control measures of thermal pollution.
**13.** Discuss various sources of marine pollution. How can you prevent pollution of our oceans ?
**14.** What are the major sources of soil pollution ? How does soil pollution affect soil productivity ? What measures can be taken to prevent soil pollution.
**15.** Define radioactivity. Mention the sources of radioactivity.
**16.** What type of the damage ionisation radiations can cause ?
**17.** Classify solid waste. What are the sources of urban and industrial solid wastes ?
**18.** What adverse effects can solid wastes cause ? How can the solid waste be managed ?
**19.** How can you, as an individual, prevent environmental pollution ? Why such an effort at individual level is important ?
**20.** Write short notes on :
(*a*) Donora air pollution episode
(*b*) Bhopal gas tragedy

(*c*) Love canal tragedy

(*d*) Chernobyl nuclear disaster.

**21.** Why do earthquakes occur ? Explain the case of any earthquake that occurred in India.

**22.** Write notes on.

(*a*) Floods

(*b*) Landslides

(*c*) Cyclones.

Unit

# 6 Social Issues and the Environment

Human beings live in both natural and social world. Our technological development has strong impacts on the natural as well as the social components. When we talk of development, it cannot be perceived as development only for a privileged few who would have a high standard of living and would derive all the benefits. Development also does not mean an increase in the GNP (Gross National Product) of a few affluent nations. Development has to be visualized in a holistic manner, where it brings benefits to all, not only for the present generation, but also for the future generations.

There is an urgent need to inter-link the social aspects with development and environment. In this unit we shall discuss various social issues in relation to environment.

## ■ FROM UNSUSTAINABLE TO SUSTAINABLE DEVELOPMENT

**Sustainable development is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."** This definition was given by the Norwegian Prime Minister, G.H. Brundtland, who was also the Director of World Health Organisation (WHO). Today sustainable development has become a buzz word and hundreds of programmes have been initiated in the name of sustainable development. If you want to test whether or not a proposal will achieve the goals of sustainability just try to find out the following. Does it protect our biodiversity? Does it prevent soil erosion? Does it slow down population growth? Does it increase forest cover? Does it cut off the emissions of CFC, SOx, NOx and $CO_2$? Does it reduce waste generation and does it bring benefits to all? These are only a few parameters for achieving sustainable growth.

Until now development has been human-oriented, that too mainly, for a few rich nations. They have touched the greatest heights

of scientific and technological development, but at what cost? The air we breathe, the water we drink and the food we eat have all been badly polluted. Our natural resources are just dwindling due to over exploitation. If growth continues in the same way, very soon we will be facing a "doom's day" - as suggested by Meadows *et al* (1972) in their world famous academic report "***The Limits to Growth***" This is unsustainable development which will lead to a collapse of the inter-related systems of this earth.

Although the fears about such unsustainable growth and development started in 1970's, yet a clear discussion on sustainable development emerged on an international level in 1992, in the UN Conference on Environment and Development (UNCED), popularly known as The Earth Summit, held at Rio de Janeiro, Brazil. The Rio Declaration aims at "*a new and equitable global partnership through the creation of new levels of cooperation among states ….*" Out of its five significant agreements **Agenda-21** proposes a global programme of action on sustainable development in social, economic and political context for the 21st Century.

These are the key aspects for sustainable development:

(*a*) **Inter-generational equity**: This emphasizes that we should minimize any adverse impacts on resources and environment for future generations i.e. we should hand over a safe, healthy and resourceful environment to our future generations. This can be possible only if we stop over-exploitation of resources, reduce waste discharge and emissions and maintain ecological balance.

(*b*) **Intra-generational equity**: This emphasizes that the development processes should seek to minimize the wealth gaps within and between nations. The Human Development Report of United Nations (2001) emphasizes that the benefits of technology should seek to achieve the goals of intra-generational equity. The technology should address to the problems of the developing countries, producing drought tolerant varieties for uncertain climates, vaccines for infectious diseases, clean fuels for domestic and industrial use. This type of technological development will support the economic growth of the poor countries and help in narrowing the wealth gap and lead to sustainability.

**Measures for Sustainable Development:** Some of the important measures for sustainable development are as follows:

- **Using appropriate technology** is one which is locally adaptable, eco-friendly, resource-efficient and culturally suitable. It mostly involves local resources and local labour. Indigenous technologies are more useful, cost-effective and sustainable.

Nature is often taken as a model, using the natural conditions of that region as its components. This concept is known as "*design with nature*".

The Technology should use less of resources and should produce minimum waste.

- **Reduce, Reuse, Recycle approach**: The 3-R approach advocating minimization of resource use, using them again and again instead of passing it on to the waste stream and recycling the materials goes a long way in achieving the goals of sustainability. It reduces pressure on our resources as well as reduces waste generation and pollution.
- **Prompting environmental education and awareness:** Making environmental education the centre of all learning process will greatly help in changing the thinking and attitude of people towards our earth and the environment. Introducing the subject right from the school stage will inculcate a feeling of belongingness to earth in the small children. 'Earth thinking' will gradually get incorporated in our thinking and action which will greatly help in transforming our life styles to sustainable ones.
- **Resource utilization as per carrying capacity**: Any system can sustain a limited number of organisms on a long-term basis which is known as its **carrying capacity**. In case of human beings, the carrying capacity concept becomes all the more complex. It is because unlike other animals, human beings, not only need food to live, but need so many other things to maintain the quality of life.

Sustainability of a system depends largely upon the carrying capacity of the system. If the carrying capacity of a system is crossed (say, by over exploitation of a resource), environmental degradation starts and continues till it reaches a point of no return.

Carrying capacity has two basic components:

- **Supporting capacity** i.e. the capacity to regenerate
- **Assimilative capacity** i.e. the capacity to tolerate different stresses.

In order to attain sustainability it is very important to utilize the resources based upon the above two properties of the system. Consumption should not exceed regeneration and changes should not be allowed to occur beyond the tolerance capacity of the system.

### The Indian Context

India has still to go a long way in implementing the concept of sustainable development. We have to lay emphasis on framing a well-planned strategy for our developmental activity while increasing our economic growth. We have tremendous natural diversity as well as a huge population which makes planning for sustainable growth all the more important and complex. The National Council of Environmental Planning and Coordination (NCPC) set up in 1972 was the focal agency in this regard. The Ministry of Environment & Forests, set up in 1985 has formulated guidelines for various developmental activities keeping in view the sustainability principles.

## ■ URBAN PROBLEMS RELATED TO ENERGY

Cities are the main centers of economic growth, trade, education, innovations and employment. Until recently, a big majority of human population lived in rural areas and their economic activities centered around agriculture, cattle rearing, fishing, hunting or some cottage industry. It was some 200 years ago, with the dawn of Industrial era, the cities showed a rapid development. Now about 50 percent of the world population lives in urban areas and there is increasing movement of rural folk to cities in search of employment. The urban growth is so fast that it is becoming difficult to accommodate all the industrial, commercial and residential facilities within a limited municipal boundary. As a result, there is spreading of the cities into the sub-urban or rural areas too, a phenomenon known as *urban sprawl.*

In developing countries too urban growth is very fast and in most of the cases it is uncontrollable and unplanned growth. In contrast to the rural set-up the urban set-up is densely populated, consumes a lot of energy and materials and generates a lot of waste.

The energy requirements of urban population are much higher than that of rural ones. This is because urban people have a higher standard of life and their life style demands more energy inputs in every sphere of life. The energy demanding activities include:

(*i*) Residential and commercial lighting.

(*ii*) Transportation means including automobiles and public transport for moving from residence to workplace.

(*iii*) Modern life-style using a large number of electrical gadgets in everyday life.

(*iv*) Industrial plants using a big proportion of energy.

(*v*) A large amount of waste generation which has to be disposed off properly using energy based techniques.

(*vi*) Control and prevention of air and water pollution which need energy dependent technologies.

Due to high population density and high energy demanding activities, the urban problems related to energy are much more magnified as compared to the rural population.

## ■ WATER CONSERVATION

Water being one of the most precious and indispensable resources needs to be conserved. The following strategies can be adopted for conservation of water.

(*i*) **Decreasing run-off losses**: Huge water-loss occurs due to run-off on most of the soils, which can be reduced by allowing most of the water to infiltrate into the soil. This can be achieved by using contour cultivation, terrace farming, water spreading, chemical treatment or improved water-storage system.

- **Contour cultivation** on small furrows and ridges across the slopes trap rainwater and allow more time for infiltration. Terracing constructed on deep soils have large water-storage capacity. On gentle slopes trapped run off is spread over a large area for better infiltration.
- **Conservation-bench terracing** involves construction of a series of benches for catching the run off water.
- **Water spreading** is done by channeling or lagoon-levelling. In channeling, the water-flow is controlled by a series of diversions with vertical intervals. In lagoon leveling, small depressions are dug in the area so that there is temporary storage of water.
- **Chemical wetting agents (Surfactants)** increase the water intake rates when added to normal irrigated soils.
- **Surface crop residues,** Tillage, mulch, animal residues etc. help in reducing run-off by allowing more time for water to penetrate into the land.
- **Chemical conditioners** like gypsum ($CaSO_4.2H_2O$) when applied to sodic soils improve soil permeability and reduce run off. Another useful conditioner is HPAN (hydrolysed polyacrylonitrile).

- **Water-storage structures** like farm ponds, dug-outs etc. built by individual farmers can be useful measures for conserving water through reduction of runoff.

(*ii*) **Reducing evaporation losses**: This is more relevant in humid regions. Horizontal barriers of asphalt placed below the soil surface increase water availability and increase crop yield by 35-40%. This is more effective on sandy soil but less effective on loamy sand soils.

A co-polymer of starch and acrylonitrile called 'super slurper' has been reported to absorb water upto 1400 times its weight. The chemical has been found to be useful for sandy soils.

(*iii*) **Storing water in soil**: Storage of water takes place in the soil root zone in humid regions when the soil is wetted to field capacity. By leaving the soil fallow for one season water can be made available for the crop grown in next season.

(*iv*) **Reducing irrigation losses**

- Use of lined or covered canals to reduce seepage.
- Irrigation in early morning or late evening to reduce evaporation losses.
- Sprinkling irrigation and drip irrigation to conserve water by 30-50%.
- Growing hybrid crop varieties with less water requirements and tolerance to saline water help conserve water.

(*v*) **Re-use of water**

- Treated wastewater can be used for ferti-irrigation.
- Using grey water from washings, bath-tubs etc. for watering gardens, washing cars or paths help in saving fresh water.

(*vi*) **Preventing wastage of water:** This can be done in households, commercial buildings and public places.

- Closing taps when not in use
- Repairing any leakage from pipes
- Using small capacity flush in toilets.

(*vii*)**Increasing block pricing**: The consumer has to pay a proportionately higher bill with higher use of water. This helps in economic use of water by the consumers.

## ■ RAINWATER HARVESTING

**Rainwater harvesting is a technique of increasing the recharge of groundwater by capturing and storing rainwater. This is done by constructing special water-harvesting structures like dug wells, percolation pits, lagoons, check dams etc.** Rainwater, wherever it falls, is captured and pollution of this water is prevented. Rainwater harvesting is not only proving useful for poor and scanty rainfall regions but also for the rich ones.

The annual average rainfall in India is 1200 mm, However, in most places it is concentrated over the rainy season, from June to September. It is an astonishing fact that Cherapunji, the place receiving the second highest annual rainfall as 11000 mm still suffers from water scarcity. The water flows with run off and there is little vegetation to check the run off and allow infiltration. Till now there is hardly any rain-water harvesting being done in this region, thereby losing all the water that comes through rainfall.

Rainwater harvesting has the following objectives:

(*i*) to reduce run off loss

(*ii*) to avoid flooding of roads

(*iii*) to meet the increasing demands of water

(*iv*) to raise the water table by recharging ground water

(*v*) to reduce groundwater contamination

(*vi*) to supplement groundwater supplies during lean season.

Rainwater can be mainly harvested by any one of the following methods:

(*i*) by storing in tanks or reservoirs above or below ground.

(*ii*) by constructing pits, dug-wells, lagoons, trench or check-dams on small rivulets

(*iii*) by recharging the groundwater.

Before adopting a rain-water harvesting system, the soil characteristics, topography, rainfall pattern and climatic conditions should be understood.

### Traditional Rain Water Harvesting

In India, it is an old practice in high rainfall areas to collect rainwater from roof-tops into storage tanks. In foot hills, water flowing from springs are collected by embankment type water storage. In Himalayan foot-hills people use the hollow bamboos as pipelines to transport the water of natural springs. Rajasthan is known for its *'tankas'* (underground tanks) and *khadins* (embankments) for harvesting rainwater.

In our ancient times we had adequate *Talaabs*, *Baawaris*, *Johars, Hauz* etc. in every city, village and capital cities of our kings and lords, which were used to collect rain-water and ensured adequate water supply in dry periods.

### Modern Techniques of Rain Water Harvesting

In arid and semi-arid regions artificial ground water recharging is done by constructing shallow percolation tanks. Check-dams made of any suitable native material (brush, poles, rocks, plants, loose rocks, wire-nets, stones, slabs, sacks etc.) are constructed for harvesting runoff from large catchment areas. Rajendra Singh of Rajasthan popularly known as "water man" has been doing a commendable job for harvesting rain-water by building checkdams in Rajasthan and he was honoured with the prestigious Magsaysay Award for his work.

Groundwater flow can be intercepted by building groundwater dams for storing water underground. As compared to surface dams, groundwater dams have several advantages like minimum evaporation loss, reduced chances of contamination etc.

In roof top rainwater harvesting, which is a low cost and effective technique for urban houses and buildings, the rain-water from the top of the roofs is diverted to some surface tank or pit through a delivery

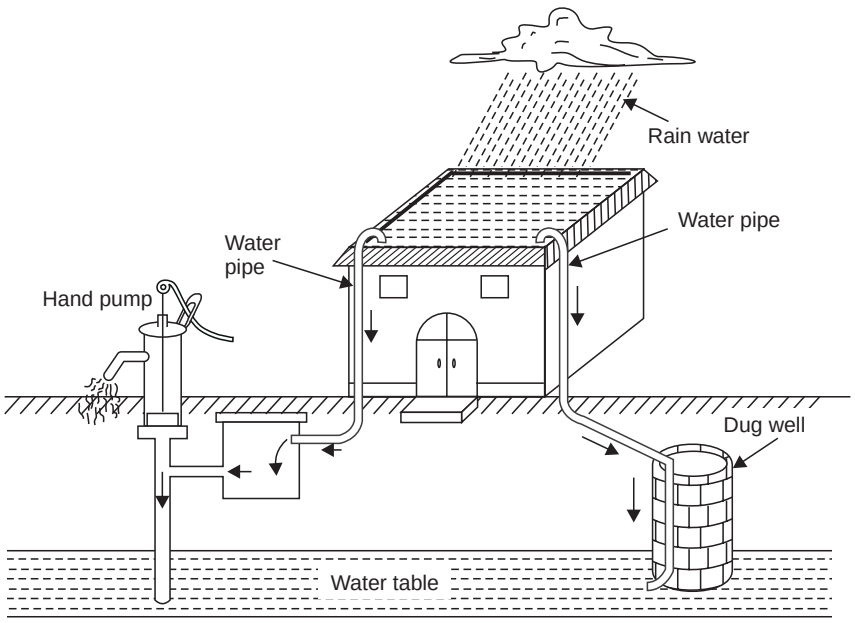



Fig. 6.1. Roof-top rainwater harvesting by recharging (*i*) through hand pump or (*ii*) through abondoned dugwell.

system which can be later used for several purposes. Also, it can be used to recharge underground aquifers by diverting the stored water to some abandoned dug-well or by using a hand pump (Fig. 6.1).

All the above techniques of rainwater harvesting are low-cost methods with little maintenance expenses. Rainwater harvesting helps in recharging the aquifers, improves groundwater quality by dilution, improves soil moisture and reduces soil erosion by minimizing run-off water.

## ■ WATERSHED MANAGEMENT

The land area drained by a river is known as the river basin. The **watershed is defined as the land area from which water drains under gravity to a common drainage channel. Thus, watershed is a delineated area with a well-defined topographic boundary and one water outlet**. The watershed can range from a few square kilometers to few thousand square kilometers in size. In the watershed the hydrological conditions are such that water becomes concentrated within a particular location like a river or a reservoir, by which the watershed is drained. The watershed comprises complex interactions of soil, landform, vegetation, land use activities and water. People and animals are an integral part of a watershed having mutual impacts on each other. We may live anywhere, we would be living in some watershed.

A watershed affects us as it is directly involved in sustained food production, water supply for irrigation, power generation, transportation as well as for influencing sedimentation and erosion, vegetation growth, floods and droughts. Thus, management of watersheds, treating them as a basic functional unit, is extremely important and the first such Integrated Watershed Management was adopted in 1949 by the Damodar Valley Corporation.

**Watershed degradation:** The watersheds are very often found to be degraded due to uncontrolled, unplanned and unscientific land use activities. Overgrazing, deforestation, mining, construction activities, industrialization, shifting cultivation, natural and artificial fires, soil erosion and ignorance of local people have been responsible for degradation of various watersheds.

**Objectives of Watershed Management:** Rational utilization of land and water resources for optimum production causing minimum damage to the natural resources is known as watershed management. The objectives of watershed management are as follows:

(*i*) To rehabilitate the watershed through proper land use adopting conservation strategies for minimizing soil erosion and moisture retention so as to ensure good productivity of the land for the farmers.

(*ii*) To manage the watershed for beneficial developmental activities like domestic water supply, irrigation, hydropower generation etc.

(*iii*) To minimize the risks of floods, droughts and landslides.

(*iv*) To develop rural areas in the region with clear plans for improving the economy of the region.

### Watershed Management Practices

In the Fifth Five Year Plan, watershed management approach was included with a number of programmes for it and a national policy was developed. In watershed management, the aspects of development are considered with regard to the availability of resources.

The practices of conservation and development of land and water are taken up with respect to their suitability for peoples' benefit as well as sustainability. Various measures taken up for management include the following:

(*i*) **Water harvesting:** Proper storage of water is done with provision for use in dry seasons in low rainfall areas. It also helps in moderation of floods.

(*ii*) **Afforestation and Agroforestry:** In watershed development, afforestation and crop plantation play a very important role. They help to prevent soil erosion and retention of moisture. In high rainfall areas woody trees are grown in between crops to substantially reduce the runoff and loss of fertile soil. In Dehradun, trees like *Eucalyptus* and *Leucaena* and grasses like *Chrysopogon* are grown along with maize or wheat to achieve the above objectives. Woody trees grown successfully in such agroforestry programmes include *Dalbergia sissoo* (Sheesham), *Tectona grandis* (Teak) and *Acacia nilotica* (Keekar) which have been used in watershed areas of river Yamuna.

(*iii*) **Mechanical measures for reducing soil erosion and runoff losses:** Several mechanical measures like terracing, bunding, bench terracing, no-till farming, contour cropping, strip cropping etc. are used to minimize runoff and soil erosion particularly on the slopes of watersheds. Bunding has proved to be a very useful method in reducing runoff, peak discharge and soil loss in Dehradun and Siwaliks.

(*iv*) **Scientific mining and quarrying:** Due to improper mining, the hills lose stability and get disturbed resulting in landslides, rapid erosion etc. Contour trenching at an interval of 1 meter on overburden dump, planting some soil binding plants like *Ipomoea* and *Vitex* and draining of water courses in the mined area are recommended for minimizing the destructive effects of mining in watershed areas.

(*v*) **Public participation:** People's involvement including the farmers and tribals is the key to the success of any watershed management programme, particularly the soil and water conservation. People's cooperation as well as participation has to be ensured for the same. The communities are to be motivated for protecting a freshly planted area and maintaining a water harvesting structure implemented by the government or some external agency (NGO) independently or by involving the local people. Properly educating the people about the campaign and its benefits or sometimes paying certain incentives to them can help in effective people's participation.

Successful watershed management has been done at Sukhomajri Panchkula, Haryana through active participation of the local people.

Watershed management in Himalayan region is of vital importance since most of the watersheds of our country lie here. Several anthropogenic activities accelerate its slope instability which need to be prevented and efforts should be made to protect the watershed by preventing overgrazing, terracing and contour farming to check runoff and erosion etc. On steeper slopes with sliding faces, straw mulching tied with thin wires and ropes helps in establishing the vegetation and stabilizing the slopes.

## ■ RESETTLEMENT AND REHABILITATION ISSUES

### Problems and Concerns

Economic development raises the quality and standard of living of the people of a country. Developmental projects are planned to bring benefits to the society. However, in the process of development, very often there is over-exploitation of natural resources and degradation of the environment. Besides this, quite often, the native people of the project site are directly affected. These native people are generally the poorest of the poor, underpriviledged tribal people. Various types of projects result in the displacement of the native people who undergo

tremendous economic and psychological distress, as the socio-economic and ecological base of the local community is disturbed.

(*a*) **Displacement problems due to dams:** The big river valley projects have one of the most serious socio-economic impacts due to large scale displacement of local people from their ancestral home and loss of their traditional profession or occupation. India is one of countries in the world leading in big dam construction and in the last 50 years more than 20 million people are estimated to have been directly or indirectly affected by these dams.

The **Hirakund Dam** has displaced more than 20,000 people residing in about 250 villages. The **Bhakra Nangal Dam** was constructed during 1950's and till now it has not been possible to rehabiltate even half of the displaced persons.

Same is the case with **Tehri Dam** on the river Bhagirathi, construction of which was green signalled after three decades of long campaign against the project by the noted activist Sunderlal Bahuguna the propagator of **Chipko Movement** . The immediate impact of the Tehri Dam would be on the 10,000 residents of the Tehri town. While displacement is looming large over the people, rehabilitation has become a more burning issue.

**CASE STUDY**

The much debated **Sardar Sarovar Project** which plans to build 30 big, 135 medium and 3000 minor dams on the Narmada river and its tributaries is estimated to submerge almost as much area as it is meant to irrigate. A total of 573 villages, consisting of about three lakh people are going to be affected due to submergence under water. As a result of the big dams the community rights of the tribals is breached. It is a traumatic experience to get uprooted from ones native place where its generations have lived and move to a new place as a total stranger. Very often the family breaks up. It is a big price that the tribals have to pay for a big dam project which is supposed to bring happiness and prosperity to the country. In return of this big sacrifice, the tribals must be given adequate compensation in the form of land, jobs, cash compensation etc. and care should be taken to improve their quality of life.

(*b*) **Displacement due to Mining:** Mining is another developmental activity, which causes displacement of the native people. Several thousands of hectares of land area is covered in mining operation and the native people are displaced. Sometimes displacement of local people is due to accidents occurring in mined areas like subsidence of land that often leads to shifting of people.

**CASE STUDY**

**Jharia coal fields, Jharkhand** have been posing a big problem to the local residents due to underground fires and they are asked to vacate the area. The proposal of large scale evacuation of about 0.3 million population of Jharia immediately raises the question of their relocation and rehabilitation for which proper planning is required. Some 115 crores of rupees have been spent to put out the fires since 1976, still the problem persists.

The people of Jharia are being asked to evacuate the area, but till now there is no altenative land and rehabilitation package prepared. As a result of it, the local people have formed a "Jharia coalfield Bachao Samiti". They have apprehensions that they are going to be left in the lurch. The latest estimates show than about Rs. 18,000 crores will be spent for shifting the Jharia population while the cost for extinguishing the fire would be around 8,000 crore. Perhaps scientific fire-fighting will prevent the Jharia residents from undergoing the hardship of displacement.

(*c*) **Displacement due to Creation of National Parks:** When some forest area is covered under a National Park, it is a welcome step for conservation of the natural resources. However, it also has a social aspect associated with it which is often neglected. A major portion of the forest is declared as core-area, where the entry of local dwellers or tribals is prohibited. When these villagers are deprived of their ancestral right or access to the forests, they usually retaliate by starting destructive activities. There is a need to look into their problems and provide them some employment.

**CASE STUDY**

The tribals belonging to Tharu Community in 142 villages in Bihar in the **Valmiki Tiger Reserve** area in the district of West Champaran feel that they have been deprived of their legitimate ancestral rights to collect firewood and fodder from the forest.

*Contd.*

Their employment is also lost due to the 'Project Tiger' initiative. The jobless villagers feel cheated and are found to indulge in destruction of forest and forest wealth in connivance with foreign agents who supply them arms and ammunition for illegal logging and poaching. In order to stop the local tribals from becoming criminals, the foremost effort of the planners should be to compensate for the loss to the locals by providing them job opportunities.

The **Wayanad Wildlife Sanctuary** in Kerala has caused displacement of 53,472 tribal families. At the time of its initiation it was decided to transfer land to these tribal families in order to settle them. However, till 2003 only 843 families could get the land. As a result of this the tribals felt cheated and in January, 2003 they encroached into the forest in large numbers, cut down the trees, started constructing huts and digging wells causing a violent encounter with the forest officials, ultimately causing injuries and deaths to the people.

## ■ REHABILITATION ISSUES

The United Nations Universal Declaration on Human Rights [Article 25(1)] has declared that **right to housing is a basic human right**.

In India, most of the displacements have resulted due to land acquisition by the government for various reasons. For this purpose, the government has the Land Acquisition Act, 1894 which empowers it to serve notice to the people to vacate their lands if there is a need as per government planning. Provision of cash compensation in lieu of the land vacated exists in section 16 of the Act. The major issues related to displacement and rehabilitation are as follows:

(*i*) Tribals are usually the most affected amongst the displaced who are already poor. Displacement further increases their poverty due to loss of land, home, jobs, food insecurity, loss of access to common property assets, increased morbidity and mortality and social isolation.

(*ii*) Break up of families is an important social issue arising due to displacement in which the women are the worst affected and they are not even given cash/land compensation.

(*iii*) The tribals are not familiar with the market policies and trends. Even if they get cash compensation, they get alienated in the modern economic set-up.

(*iv*) The land acquisition laws ignore the communal ownership of property, which is an inbuilt system amongst the tribals. Thus the tribals lose their communitarian basis of economic and cultural existence. They feel like fish out of water.

(*v*) Kinship systems, marriages, social and cultural functions, their folk-songs, dances and activities vanish with their displacement. Even when they are resettled, it is individual-based resettlement, which totally ignores communal settlement.

(*vi*) Loss of identity and loss of the intimate link between the people and the environment is one of the biggest loss. The age-long indigenous knowledge, which has been inherited and experienced by them about the flora, fauna, their uses etc. gets lost.

### Rehabilitation Policy

There is a need for a comprehensive National Rehabilitation Policy. Different states are following different practices in this regard.

## CASE STUDIES

In case of **Sardar Sarovar Project**, Gujarat Government is formulating its policy through various government resolutions. It has decided that each landed oustee shall be entitled to allotment of irrigable land in the state which he chooses for his resettlement. The area of the land would be equal to that owned by him earlier and the minimum land given to an oustee would be 2 hectares. However, there are problems of landless oustees and those natives who were cultivating forest land. The cut-off date for identifying an adult son in a family has not been fixed. It is important since the adult son is to be treated as a separate family. The people of 20 submerged villages in Gujarat have been resettled at different locations leading to disintegration of joint families.

The case of **Pong Dam** is different. The dam was constructed on Beas River in Himachal Pradesh in 1960, while it was a part of Panjab. The water is harnessed to irrigate Rajasthan. Rajasthan, therefore, agreed to provide land to the oustees in the command area of Indira Gandhi Canal. However, to carry Beas Water to Rajasthan, another dam had to be built adding 20,722 more families that were displaced and had to be resettled by Rajasthan. Out of 30,000 families uprooted due to Pong dam, only 16,000 were considered eligible for allotment, as only they were bonafide

*Contd.*

cultivators for whom 2.25 lakh acre land was earmarked. What happened to the rest of the 14,000 families is not answered. Panjab, which is one of the beneficiaries of the dam is totally out of the rehabilitation issue. Only Rajasthan and Himachal Pradesh are trying to settle the matter. Even those who have been settled, they are in resettlement sites in desert bordering Pakistan, more than thousand kilometers from their native place, thus breaking their kinship ties.

There is a need to raise public awareness on these issues to bring the resettlement and rehabilitation plans on a humane footing and to honour the human rights of the oustees.

## ■ ENVIRONMENTAL ETHICS—Issues and Possible Solutions

Environmental ethics refers to the issues, principles and guidelines relating to human interactions with their environment. It is rightly said, "*The environmental crisis is an outward manifestation of the crisis of mind and spirit*". It all depends on how do we think and act. If we think "*Man is all powerful and the supreme creature on this earth and man is the master of nature and can harness it at his will", it reflects our* **human-centric thinking**. *On the other hand, if we think "Nature has provided us with all the resources for leading a beautiful life and she nourishes us like a mother, we should respect her and nurture her"*, this is an **earth-centric thinking**.

The first view urges us to march ahead gloriously to conquer the nature and establish our supremacy over nature through technological innovations, economic growth and development without much botheration to care for the damage done to the planet earth. The second view urges us to live on this earth as a part of it, like any other creation of Nature and live sustainably. So, we can see that our acts will follow what we think. If we want to check the environmental crisis, we will have to transform our thinking and attitude. That in turn, would transform our deeds, leading to a better environment and better future.

These two world-views are discussed here in relation to environmental protection:

(*a*) **Anthropocentric Worldview:** This view is guiding most industrial societies. It puts human beings in the center giving them the highest status. Man is considered to be most capable for managing the planet earth. The guiding principles of this view are:

(*i*) Man is the planet's most important species and is the in-charge of the rest of nature.

(*ii*) Earth has an unlimited supply of resources and it all belongs to us.

(*iii*) Economic growth is very good and more the growth, the better it is, because it raises our quality of life and the potential for economic growth is unlimited.

(*iv*) A healthy environment depends upon a healthy economy.

(*v*) The success of mankind depends upon how good managers we are for deriving benefits for us from nature.

(*b*) **Eco-centric Worldview:** This is based on earth-wisdom. The basic beliefs are as follows:

(*i*) Nature exists not for human beings alone, but for all the species.

(*ii*) The earth resources are limited and they do not belong only to human beings.

(*iii*) Economic growth is good till it encourages earth-sustaining development and discourages earth-degrading development.

(*iv*) A healthy economy depends upon a healthy environment.

(*v*) The success of mankind depends upon how best we can cooperate with the rest of the nature while trying to use the resources of nature for our benefit.

Environmental ethics can provide us the guidelines for putting our beliefs into action and help us decide what to do when faced with crucial situations. Some important ethical guidelines known as **Earth ethics** or **Environmental Ethics** are as follows:

- You should love and honour the earth since it has blessed you with life and governs your survival.
- You should keep each day sacred to earth and celebrate the turning of its seasons.
- You should not hold yourself above other living things and have no right to drive them to extinction.
- You should be grateful to the plants and animals which nourish you by giving you food.
- You should limit your offsprings because too many people will overburden the earth.
- You should not waste your resources on destructive weapons.
- You should not run after gains at the cost of nature, rather should strive to restore its damaged majesty.
- You should not conceal from others the effects you have caused by your actions on earth.

- You should not steal from future generations their right to live in a clean and safe planet by impoverishing or polluting it.
- You should consume the material goods in moderate amounts so that all may share the earth's precious treasure of resources.

If we critically go through the above ten commandments for earth ethics and reflect upon the same, we will find that various religions teach us the same things in one form or the other. Our Vedas have glorified each and every component of nature as gods or goddesses so that people have a feeling of reverence for them. Our religious and cultural rituals make us perform such actions that would help in the conservation of nature and natural resources. The concept of 'ahimsa' (non-violence) in Buddhism and Jainism ensure the protection and conservation of all forms of life, thereby keeping the ecological balance of the earth intact. Our teachings on "*having fewer wants*" ensures to put "*limits to growth*" and thus, guide us to have an eco-centric life style.

## ■ CLIMATE CHANGE

Climate is the average weather of an area. It is the general weather conditions, seasonal variations and extremes of weather in a region. Such conditions which average over a long period- at least 30 years is called climate.

The **Intergovernmental Panel on Climate Change (IPCC)** in 1990 and 1992 published best available evidence about past climate change, the green house effect and recent changes in global temperature. It is observed that earth's temperature has changed considerably during the geological times. It has experienced several glacial and interglacial periods. However, during the past 10,000 years of the current interglacial period the mean average temperature has fluctuated by 0.5-1°C over 100 to 200 year period. We have relatively stable climate for thousands of years due to which we have practised agriculture and increased in population. Even small changes in climatic conditions may disturb agriculture that would lead to migration of animals including humans.

Anthropogenic (man-made) activities are upsetting the delicate balance that has established between various components of the environment. Green house gases are increasing in the atmosphere resulting in increase in the average global temperature.

This may upset the hydrological cycle, result in floods and droughts in different regions of the world, cause sea level rise, changes in agriculture productivity, famines and death of humans as well as live stock.

The global change in temperature will not be uniform everywhere and will fluctuate in different regions. The places at higher latitudes will be warmed up more during late autumn and winter than the places in tropics. Poles may experience 2 to 3 times more warming than the global average, while warming in the tropics may be only 50 to 100% on an average. The increased warming at poles will reduce the thermal gradient between the equator and high latitude regions decreasing the energy available to the heat engine that drives the global weather machine. This will disturb the global pattern of winds and ocean currents as well as the timing and distribution of rainfall. Shifting of ocean currents may change the climate of Iceland and Britain and may result in cooling at a time when rest of the world warms. By a temperature increase of 1.5 to 4.5°C the global hydrological cycle is expected to intensify by 5 to 10%. Disturbed rainfall will result in some areas becoming wetter and the others drier. Although rainfall may increase, higher temperatures will result in more evapo-transpiration leading to annual water deficit in crop fields.

## ■ GLOBAL WARMING

Troposphere, the lowermost layer of the atmosphere, traps heat by a natural process due to the presence of certain gases. This effect is called **Green House Effect** as it is similar to the warming effect observed in the horticultural green house made of glass. The amount of heat trapped in the atmosphere depends mostly on the concentrations of "heat trapping" or "green house" gases and the length of time they stay in the atmosphere. The major green house gases are carbon dioxide, ozone, methane, nitrous oxide, chlorofluorocarbons (CFCs) and water vapours. The average global temperature is 15°C. In the absence of green house gases this temperature would have been –18°C. Therefore, Green House Effect contributes a temperature rise to the tune of 33°C. Heat trapped by green house gases in the atmosphere keeps the planet warm enough to allow us and other species to exist. The two predominant green house gases are water vapours, which are controlled by hydrological cycle, and carbon dioxide, which is controlled mostly by the global carbon cycle. While the levels of water vapour in the troposphere have relatively remained constant, the levels of carbon dioxide have increased. Other

gases whose levels have increased due to human activities are methane, nitrous oxide and chlorofluorocarbons. Deforestation has further resulted in elevated levels of carbon dioxide due to non-removal of carbon dioxide by plants through photosynthesis.

Warming or cooling by more than 2°C over the past few decades may prove to be disastrous for various ecosystems on the earth including humans, as it would alter the conditions faster than some species could adapt or migrate. Some areas will become inhabitable because of drought or floods following a rise in average sea level.

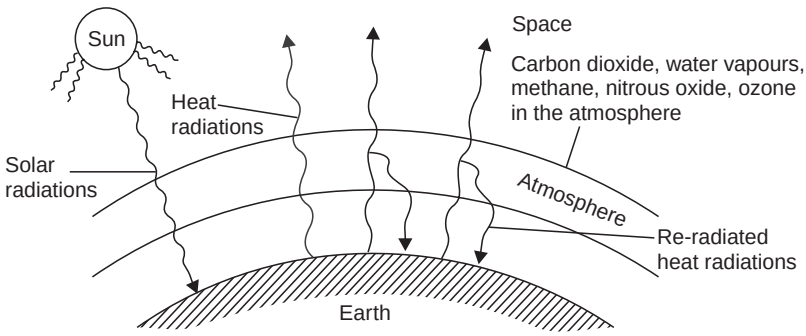



Fig. 6.2. The greenhouse effect.

## Greenhouse Gases

The phenomenon that worries the environmental scientists is that due to anthropogenic activities there is an increase in the concentration of the greenhouse gases in the air that absorb infra-red light containing heat and results in the re-radiation of even more of the out going thermal infra-red energy, thereby increasing the average surface temperature beyond 15°C. The phenomenon is referred to as the **enhanced green house effect** to distinguish its effect from the one that has been operating naturally for millennia.

The greenhouse gases present in the troposphere and resulting in an increase in the temperature of air and the earth are discussed here:

## Carbon dioxide

It contributes about 55% to global warming from green house gases produced by human activity. Industrial countries account for about 76% of annual emissions. The main sources are fossil fuel burning (67%) and deforestation, other forms of land clearing and burning (33%). $CO_2$ stays in the atmosphere for about 500 years. $CO_2$ concentration in the atmosphere was 355 ppm in 1990 that is increasing at a rate of 1.5 ppm every year.

### Chlorofluorocarbons (CFCs)

These are believed to be responsible for 24% of the human contribution to greenhouse gases. They also deplete ozone in the stratosphere. The main sources of CFCs include leaking air conditioners and refrigerators, evaporation of industrial solvents, production of plastic foams, aerosols, propellants etc. CFCs take 10-15 years to reach the stratosphere and generally trap 1500 to 7000 times more heat per molecule than $CO_2$ while they are in the troposphere. This heating effect in the troposphere may be partially offset by the cooling caused when CFCs deplete ozone during their 65 to 110 years stay in the stratosphere. Atmospheric concentration of CFC is 0.00225 ppm that is increasing at a rate of 0.5% annually.

### Methane ($CH_4$)

It accounts for 18% of the increased greenhouse gases. Methane is produced when bacteria break down dead organic matter in moist places that lack oxygen such as swamps, natural wetlands, paddy fields, landfills and digestive tracts of cattle, sheep and termites. Production and use of oil and natural gas and incomplete burning of organic material are also significant sources of methane. Methane stays in the atmosphere for 7-10 years. Each methane molecule traps about 25 times as much heat as a $CO_2$ molecule. Atmospheric concentration of methane is 1.675 ppm and it is increasing at a rate of 1% annually.

### Nitrous Oxide ($N_2O$)

It is responsible for 6% of the human input of green house gases. Besides trapping heat in the troposphere it also depletes ozone in the stratosphere. It is released from nylon products, from burning of biomass and nitrogen rich fuels ( especially coal ) and from the break down of nitrogen fertilizers in soil, livestock wastes and nitrate contaminated ground water. Its life span in the troposphere is 140-190 years and it traps about 230 times as much heat per molecule as $CO_2$. The atmospheric concentration of $N_2O$ is 0.3 ppm and is increasing at a rate of 0.2% annually.

### Impacts of Enhanced Greenhouse Effect

The enhanced greenhouse effect will not only cause global warming but will also affect various other climatic and natural processes.

(*i*) **Global temperature increase:** It is estimated that the earth's mean temperature will rise between 1.5 to 5.5°C by 2050 if input of

greenhouse gases continues to rise at the present rate. Even at the lower value, earth would be warmer than it has been for 10,000 years.

(*ii*) **Rise in Sea Level**: With the increase in global temperature sea water will expand. Heating will melt the polar ice sheets and glaciers resulting in further rise in sea level. Current models indicate that an increase in the average atmospheric temperature of 3°C would raise the average global sea level by 0.2–1.5 meters over the next 50–100 years.

One meter rise in sea level will inundate low lying areas of cities like Shanghai, Cairo, Bangkok, Sydney, Hamburg and Venice as well as agricultural lowlands and deltas in Egypt, Bangladesh, India, China and will affect rice productivity. This will also disturb many commercially important spawning grounds, and would probably increase the frequency of storm damage to lagoons, estuaries and coral reefs.

In India, the Lakshadweep Islands with a maximum height of 4 meters above the level may be vulnerable. Some of the most beautiful cities like Mumbai may be saved by heavy investment on embankment to prevent inundation.

Life of millions of people will be affected, by the sea level rise who have built homes in the deltas of the Ganges, the Nile, the Mekong, the Yangtze and the Mississippi rivers.

(*iii*) **Effects on Human Health**: The global warming will lead to changes in the rainfall pattern in many areas, thereby affecting the distribution of vector-borne diseases like malaria, filariasis, elephantiasis etc.

Areas which are presently free from diseases like malaria, schistosomiasis etc. may become the breeding grounds for the vectors of such diseases. The areas likely to be affected in this manner are Ethiopia, Kenya and Indonesia. Warmer temperature and more water stagnation would favour the breeding of mosquitoes, snails and some insects, which are the vectors of such diseases.

Higher temperature and humidity will increase/aggravate respiratory and skin diseases.

(*iv*) **Effects on Agriculture:** There are different views regarding the effect of global warming on agriculture. It may show positive or negative effects on various types of crops in different regions of the world. Tropical and subtropical regions will be more affected since the average temperature in these regions is already on the higher side. Even a rise of 2°C may be quite harmful to crops. Soil moisture will decrease

and evapo-transpiration will increase, which may drastically affect wheat and maize production.

Increase in temperature and humidity will increase pest growth like the growth of vectors for various diseases. Pests will adapt to such changes better than the crops.

To cope up with the changing situation drought resistant, heat resistant and pest resistant varieties of crops have to be developed.

### Measures to Check Global Warming

To slow down enhanced global warming the following steps will be important:

(*i*) Cut down the current rate of use of CFCs and fossil fuel.
(*ii*) Use energy more efficiently.
(*iii*) Shift to renewable energy resources.
(*iv*) Increase Nuclear Power Plants for electricity production.
(*v*) Shift from coal to natural gas.
(*vi*) Trap and use methane as a fuel.
(*vii*) Reduce beef production.
(*viii*) Adopt sustainable agriculture.
(*ix*) Stabilize population growth.
(*x*) Efficiently remove $CO_2$ from smoke stacks.
(*xi*) Plant more trees.
(*xii*) Remove atmospheric $CO_2$ by utilizing photosynthetic algae.

## ■ ACID RAIN

Oxides of sulfur and nitrogen originating from industrial operations and fossil fuel combustion are the major sources of acid forming gases. Acid forming gases are oxidised over several days by which time they travel several thousand kilometers. In the atmosphere these gases are ultimately converted into sulfuric and nitric acids. Hydrogen chloride emission forms hydrochloric acid. These acids cause acidic rain. Acid rain is only one component of acidic deposition. Acidic deposition is the total of wet acidic deposition (acid rain) and dry deposition.

Rain water is turned acidic when its pH falls below 5.6 (Fig. 6.3). In fact clean or natural rain water has a pH of 5.6 at 20°C because of formation of carbonic acid due to dissolution of $CO_2$ in water.

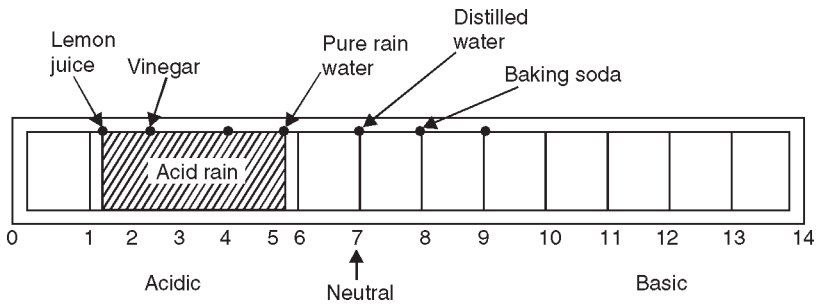



Fig. 6.3. The pH scale of common substances.

The Adirondack Lakes located in the state of New York are known to receive acid rains.

The strong acids like sulphuric acid ($H_2SO_4$) and nitric acid ($HNO_3$) dissolved or formed in rainwater dissociate or release hydrogen ions thereby increasing the acidity in rain drops.

Generally sulfuric acid forms a major fraction of acid rain, followed by nitric acid and a very small fraction of other acids. However, in urban areas calcium ($Ca^{2+}$), Magnesium ($Mg^{2+}$) and ammonium ($NH^{4+}$) ions help to neutralize the rain drops shifting the overall $H^+$ towards basic scale. The overall pH of any raindrop is due to the net effect of carbonic acid, sulfuric acid, nitric acid and other acidic constituents or any neutralizers such as ammonia.

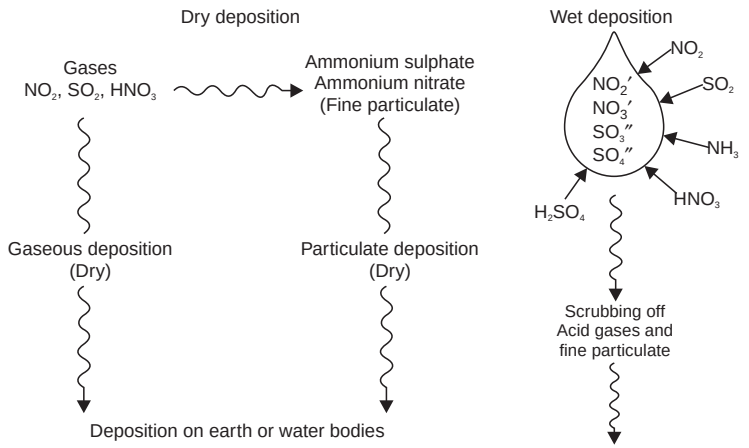



Fig. 6.4. Acid deposition (dry deposition and wet deposition).

In the absence of rain, dry deposition of acid may occur. Acid forming gases like oxides of sulphur and nitrogen and acid aerosols get deposited on the surface of water bodies, vegetation, soil and other materials. On moist surfaces or in liquids these acid forming gases can

dissolve and form acids similar to that formed in acid rain. If the oxidizers are present on the liquid surfaces then these gases undergo oxidation to form acids. Fine particles or acid droplets can act as nuclei for water to condense to form rain droplets. By such process sulfuric acid is incorporated into the droplets. In the clouds additional $SO_2$ and $NO_2$ contact the droplets and get absorbed which can be oxidized by the dissolved hydrogen peroxide ($H_2O_2$) or other oxidizers. In the droplets falling from the clouds additional acidic gases and aerosol particles get incorporated, further decreasing their pH. A unit decrease in pH value causes 10 times increase in acidity. Average pH in rainfall over eastern United States from April 1979 to March 1980 was less than 5.0. In India acid rain is recorded from certain places:

| **Name of place** | **pH of rainwater** |
|---|---|
| Kodaikanal | 5.18 |
| Minicoy | 5.52 |
| Mohanbari | 5.50 |

### Effects of acid rain

Acid rain causes a number of harmful effects below pH 5.1. The effects are visible in the aquatic system even at pH less than 5.5.

- It causes deterioration of buildings especially made of marble *e.g.* monuments like Taj Mahal. Crystals of calcium and magnesium sulphate are formed as a result of corrosion caused by acid rain.
- It damages stone statues. Priceless stone statues in Greece and Italy have been partially dissolved by acid rain.
- It damages metals and car finishes.
- Aquatic life especially fish are badly affected by lake acidification.
- Aquatic animals suffer from toxicity of metals such as aluminium, mercury, manganese, zinc and lead which leak from the surrounding rocks due to acid rain.
- It results in reproductive failure, and killing of fish.
- Many lakes of Sweden, Norway, Canada have become fishless due to acid rain.
- It damages foliage and weakens trees.
- It makes trees more susceptible to stresses like cold temperature, drought, etc. Many insects and fungi are more tolerant to acidic conditions and hence they can attack the susceptible trees and cause diseases.

### Control of Acid Rain

- Emission of $SO_2$ and $NO_2$ from industries and power plants should be reduced by using pollution control equipments.
- Liming of lakes and soils should be done to correct the adverse effects of acid rain.
- A coating of protective layer of inert polymer should be given in the interior of water pipes for drinking water.

## ■ OZONE LAYER DEPLETION

For the last 450 million years the earth has had a natural sunscreen in the stratosphere called the ozone layer. This layer filters out harmful ultraviolet radiations from the sunlight and thus protects various life forms on the earth.

Ozone is a form of oxygen. The molecule of oxygen contains two atoms whereas that of ozone contains three ($O_3$). In the stratosphere ozone is continuously being created by the absorption of short wavelength ultraviolet (UV) radiations. Ultraviolet radiations less than 242 nanometers decompose molecular oxygen into atomic oxygen (O) by photolytic decomposition.

$$O_2 + h\nu \longrightarrow O + O$$

The atomic oxygen rapidly reacts with molecular oxygen to form ozone.

$$O + O_2 + M \longrightarrow O_3 + M$$

(M is a third body necessary to carry away the energy released in the reaction).

Ozone thus formed distributes itself in the stratosphere and absorbs harmful ultraviolet radiations (200 to 320 nm) and is continuously being converted back to molecular oxygen.

$$O_3 + h\nu \longrightarrow O_2 + O$$

Absorption of UV radiations results in heating of the stratosphere.

The net result of the above reactions is an equilibrium concentration of ozone. Ozone concentration in about 24 km of the stratosphere i.e. from 16 km to 40 Km away from earth is about 10 ppm (as compared to 0.05 ppm concentration of harmful tropospheric ozone). This equilibrium is disturbed by reactive atoms of chlorine, bromine etc. which destroy ozone molecules and result is thinning of ozone layer generally called ozone hole.

The amount of atmospheric ozone is measured by 'Dobson Spectrometer' and is expressed in **Dobson units (DU)**. One DU is equivalent to a 0.01 mm thickness of pure ozone at the density it would possess if it were brought to ground level (1atm) pressure. Normally over temperate latitude its concetration is about 350 DU, over tropics it is 250 DU whereas at subpolar regions (except when ozone thinning occurs) it is on an average 450 DU. It is because of the stratospheric winds which transport ozone from tropical towards polar regions.

### Thinning of Ozone Layer

The Antarctic ozone hole was discovered by Dr Joe C. Farman and his colleagues in the British Antarctic Survey who had been recording ozone levels over this region since 1957. During spring season of south pole *i.e.* September to November each year ozone depletion is observed. Steep decline has been observed since mid 1970s with a record low concentration of 90 DU in early October of 1993.

Chlorofluorocarbons (CFC) are mainly responsible for ozone depletion in the stratosphere. CFCs are a group of synthetic chemicals first discovered by Thomas Midgley Jr. in 1930. CFC-11 and CFC-12 are the CFCs most commonly used. CFCs are used as coolants in refrigerators and air conditioners, as propellants, cleaning solvents, sterilant and in styrofoam etc. CFCs released in the troposphere reach the stratosphere and remain there for 65-110 years destroying $O_3$ molecules. In 1974, Rowland and Molina warned that CFC are lowering the concentration of ozone in the stratosphere and predicted severe consequences. It was however, in 1985 that scientists for the first time discovered that 50% (98% in some areas) of upper stratospheric ozone over Antarctica was destroyed during the Antarctic spring and early summer (September-December). At Antarctic region the temperature during winter drops to – 90°C. The winds blowing in a circular pattern over earth's poles create polar vortices. Water droplets in clouds when enter these vortices form ice crystals. CFCs get collected on the surfaces of these ice crystals and destroy ozone much faster. Similar destruction of ozone over North Pole occurs during Arctic spring and early summer (February-June). The depletion is 10-25% and it is less than that observed at south pole.

Nitrous oxide emitted by supersonic aircrafts, during combustion of fossil fuel and use of nitrogen fertilizers breaks ozone molecules. Chlorine liberated from chlorofluorocarbons also break ozone molecules. The chain reaction started in Antarctic spring *i.e.* August/ September continues till nitrogen dioxide is liberated from nitric acid formed in the stratosphere by photolysis (breakdown by sunlight).

Nitrogen dioxide combines with chlorine and stops further destruction of ozone.

### Effects of Ozone Depletion

- Ozone depletion in the stratosphere will result in more UV radiation reaching the earth especially UV-B (290-320 nm). The UV-B radiations affect DNA and the photosynthetic chemicals. Any change in DNA can result in mutation and cancer. Cases of skin cancer (basal and squamous cell carcinoma) which do not cause death but cause disfigurement will increase.
- Easy absorption of UV rays by the lens and cornea of eye will result in increase in incidents of cataract.
- Melanin producing cells of the epidermis (important for human immune system) will be destroyed by UV-rays resulting in immuno-suppression. Fair people (can't produce enough melanin) will be at a greater risk of UV exposure.
- Phytoplanktons are sensitive to UV exposure. Ozone depletion will result in decrease in their population thereby affecting the population of zooplankton, fish, marine animals, in fact the whole aquatic food chain.
- Yield of vital crops like corn, rice, soybean, cotton, bean, pea, sorghum and wheat will decrease.
- Degradation of paints, plastics and other polymer material will result in economic loss due to effects of UV radiation resulting from ozone depletion.

## ■ NUCLEAR ACCIDENTS AND HOLOCAUST

Nuclear accidents can occur at any stage of the nuclear fuel cycle. However, the possibility of reactor accidents is viewed more seriously because the effects of reactor accidents are more drastic.

Many estimates of hypothetical accidents in a nuclear power station are made. Such estimates are made taking into consideration various parameters like reactor safety measures which if fail would release large amount of reactor contents, that is, radioactive debris affecting a substantial portion of human population within a particular site in a particular area.

The modern fusion bombs (nuclear bombs) are of the explosive force of 500 kilotons and 10 megatons. In case of a world war total nuclear exchange of more than 5,000 megatons can be expected. Nuclear bombardment will cause combustion of wood, plastics, petroleum, forests etc. Large quantity of black soot will be carried to

the stratosphere. Black soot will absorb solar radiations and won't allow the radiations to reach the earth. Therefore, cooling will result. The infrared radiations which are re-radiated from the atmosphere to the earth will have very less water vapours and carbon dioxide to absorb them. If they leave the lower atmosphere the green house effect will be disturbed and cooling will occur. Due to this cooling effect, water evaporation will also reduce. Therefore, infra-red radiations absorbing water vapours will reduce in the atmosphere. This will also cause cooling. In the stratosphere there won't be significant moisture to rain-out the thick soot. So, due to nuclear explosions, a phenomenon opposite to global warming will occur. This is called **nuclear winter**. It may result in lower global temperature. Even the summer time will experience freezing temperature. It will drastically affect crop production. Crop productivity will reduce substantially causing famines and human sufferings.

The Chernobyl nuclear accident, 1986 has resulted in wide spread contamination by radioactive substances. (already mentioned in air pollution episodes). The devastation caused by nuclear bombs are not only immediate but may be long lasting. Towards, the end of World War II, bombing of Dresden, Germany caused huge firestorms. This caused particle ladden updrafts in the atmosphere.

**CASE STUDY**

In **Nuclear holocaust in Japan** 1945, two nuclear bombs were dropped on Hiroshima and Nagasaki cities of Japan. One fission bomb was dropped on Hiroshima. This holocaust (large scale destruction of human lives by fire) killed about 100,000 people and destroyed the city. This forceful explosion emitted neutrons and gamma radiations. It had the force of 12 kilotons of trinitrotoluene (TNT). The radioactive strontium (Sr90) liberated in the explosion resembles calcium and has the property of replacing calcium of the bones. As a result large scale bone-deformities occurred in the inhabitants of these cities. Even after more than 50 years the impacts of the nuclear fallout are still visible.

## ■ WASTELAND RECLAMATION

Economically unproductive lands suffering from environmental deterioration are known as wastelands. The wastelands include salt-affected lands, sandy areas, gullied areas, undulating uplands, barren hill-ridge etc. Snow covered areas, glacial areas and areas rendered

barren after Jhum cultivation are also included in wastelands. More than half of our country's geographical area (about 175 million ha) is estimated to be wasteland, thus indicating the seriousness of the problem for a country like ours which has to support 1/6th of the world's population.

Maximum wasteland areas in our country lie in Rajasthan (36 million ha) followed by M.P. and Andhra Pradesh. In Haryana the wastelands cover about 8.4% of the total land area and most of it comprises saline, sodic or sandy land areas.

Wastelands are formed by natural processes, which include undulating uplands, snow-covered lands, coastal saline areas, sandy areas etc. or by anthropogenic (man-made) activities leading to eroded, saline or waterlogged lands.

The major anthropogenic activities leading to waste land formation are deforestation, overgrazing, mining and erroneous agricultural practices. Although deserts are wastelands formed by natural process, but there are many human activities which accelerate the spreading of desert as we have already discussed.

### Wasteland Reclamation Practices

Wasteland reclamation and development in our country falls under the purview of **Wasteland Development Board**, which works to fulfill the following objectives:

- To improve the physical structure and quality of the marginal soils.
- To improve the availability of good quality water for irrigating these lands.
- To prevent soil erosion, flooding and landslides.
- To conserve the biological resources of the land for sustainable use.

Some important reclamation practices are discussed here.

(*i*) **Land development and leaching:** For reclamation of the salt affected soil, it is necessary to remove the salts from the root-zone which is usually achieved by leaching i.e. by applying excess amount of water to push down the salts. After a survey of the extent of salinity problem, soil texture, depth of impermeable layer and water table, land leveling is done to facilitate efficient and uniform application of water. After leveling and ploughing, the field is bunded in small plots and leaching is done. In continuous leaching, 0.5 to 1.0 cm water is required to remove 90% of soluble salts from each cm of the soil depending upon texture. If we use intermittent sprinkling with 25 cm water, it reduces about 90% salinity in the upper 60 cm layer.

(*ii*) **Drainage:** This is required for water-logged soil reclamation where excess water is removed by artificial drainage.

(*a*) **Surface drainage:** This is used in areas where water stands on the fields after heavy rains by providing ditches to runoff the excess water. Usually 30-45 cm deep ditches lying parallel to each other at 20-60 m distance are able to remove 5 cm of water within 24 hours.

(*b*) **Sub-surface drainage:** Horizontal sub-surface drainage is provided in the form of perforated corrugated PVC pipes or open-jointed pipes with an envelope of gravel 2-3 m below the land surface. Chances of evaporation of water leading to accumulation of salts almost become nil in this method.

The World Bank has funded sub-surface drainage system at Sampla, Rohtak (Haryana) for reducing soil salinity by this method.

(*iii*) **Irrigation Practices:** Surface irrigation with precise land leveling, smoothening and efficient hydraulic design help to reduce water logging and salinity. High frequency irrigation with controlled amount of water helps to maintain better water availability in the upper root zone. Thin and frequent irrigations have been found to be more useful for better crop yield when the irrigation water is saline as compared to few heavy irrigations.

(*iv*) **Selection of tolerant crops and crop rotations:** Tolerance of crops to salts is found to range from sensitive, semi-tolerant, tolerant to highly tolerant. Barley, sugar beet and date-palm are highly tolerant crops which do not suffer from any reduction in crop yield even at a high salinity with electrical conductivity (EC) of 10 dS/m. Wheat, sorghum, pearl millet, soyabean, mustard and coconut are salt-tolerant crops. Rice, millets, maize, pulses, sunflower, sugarcane and many vegetables like bottle gourd, brinjal etc. are semi-tolerant. These different crop combinations can be grown on saline soils.

(*v*) **Gypsum amendment:** Amendment of sodic soils with gypsum is recommended for reducing soil sodicity as calcium of gypsum replaces sodium from the exchangeable sites.

(*vi*) **Green-manures, fertilizers and biofertilizers:** Application of farm yard manure or nitrogen fertilizers have been found to improve saline soils. Green manuring with dhaincha (*Sesbania aculeata*) sunhemp or guar have also been reported to improve salt-affected soils. Blue green algae have been found to be quite promising as biofertilizers for improving salt-affected soils.

(*vii*) **Afforestation Programmes:** The National Commission on Agriculture **(NCA)** launched several afforestation schemes in the VIth plan to cope up with the problem of spreading wasteland. The National Wasteland Development Board, in the Ministry of Environment and

Forests has set a target of bringing 5 million ha of wasteland annually under firewood and fodder plantation.

(*viii*) **Social Forestry Programmes:** These programmes mostly involve strip plantation on road, rail and canal-sides, rehabilitation of degraded forest lands, farm-forestry, waste-land forest development etc.

## ■ CONSUMERISM AND WASTE PRODUCTS

Consumerism refers to the consumption of resources by the people. While early human societies used to consume much less resources, with the dawn of industrial era, consumerism has shown an exponential rise. It has been related both to the increase in the population size as well as increase in our demands due to change in life-style. Earlier we used to live a much simpler life and used to have fewer wants. In the modern society our needs have multiplied and so consumerism of resources has also multiplied.

Our population was less than 1 million for thousands of years ever since we evolved on this earth. Today we have crossed the six billion mark and are likely to reach 11 billion by 2045 as per World Bank estimates. Let us see how the changing population trends influence consumerism of natural resources and generation of wastes. Two types of conditions of population and consumerism exist.

(*i*) **People over-population**: It occurs when there are more people than available supplies of food, water and other important resources in the area. Excessive population pressure causes degradation of the limited resources, and there is absolute poverty, under-nourishment and premature deaths.

This occurs in less developed countries (LDCs). Here due to large number of people, adequate resources are not available for all. So there is less per capita consumption although overall consumption is high.

(*ii*) **Consumption over-population**: This occurs in the more developed countries (MDCs). Here population size is smaller while resources are in abundance and due to luxurious life-style per capita consumption of resources is very high. More the consumption of resources more is the waste generation and greater is the degradation of the environment.

This concept can be explained by using the model of Paul Ehrlich and John Hodlren (1972):

| Number of People | × | Per Capita use of resources | × | Waste generated per unit of resource used | = | Over all Environmental Impact |
|---|---|---|---|---|---|---|

This can be illustrated diagrammatically as shown in Fig. 6.5.

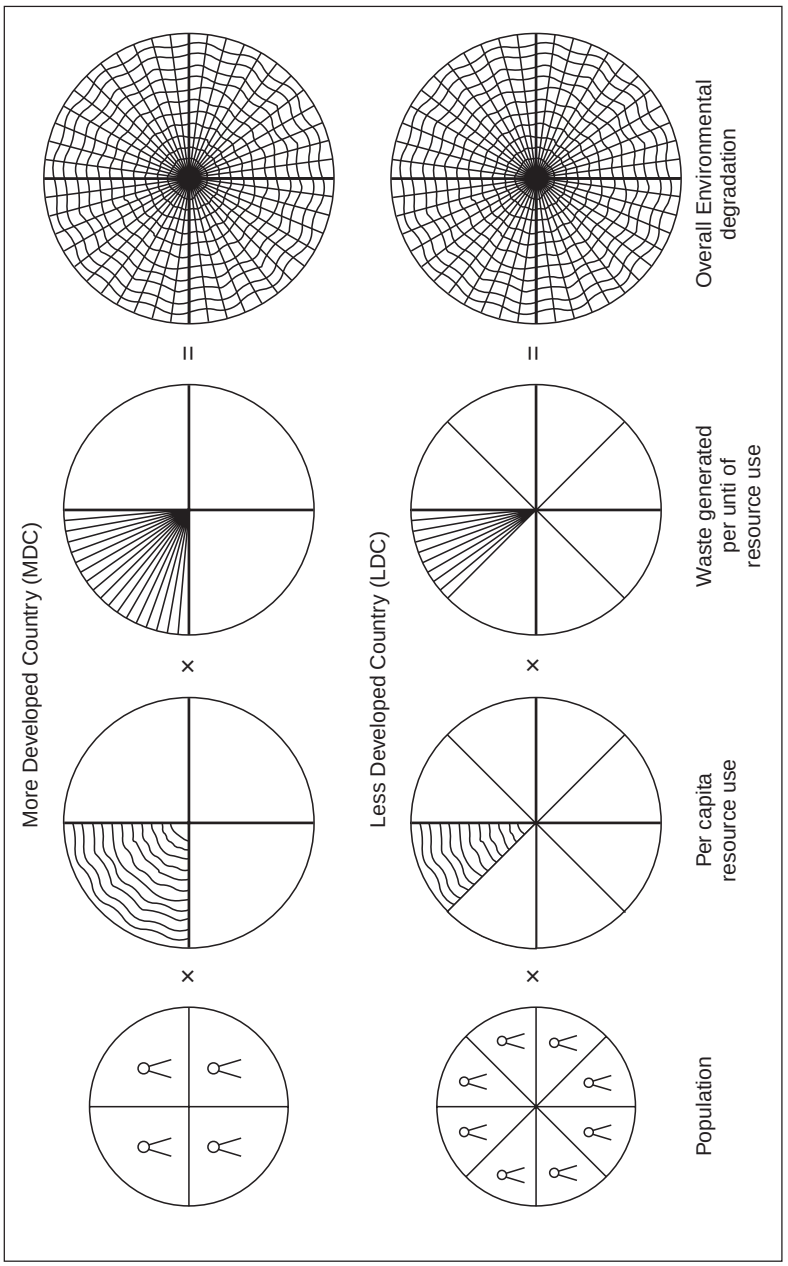



Fig. 6.5. Relationship of population, consumerism waste production and environmental impacts.

In LDC's - No. of people is very high, but per capita use of resources and waste generated are less.

In MDC's - No. of people is low, but per capita use of resources and wastes generated are very high.

The overall environmental impact of these two types of consumerism may be same or even greater in case of MDC's.

Thus, consumerism varies with the country and USA is known for maximum consumerism. The throw-away attitude and luxurious life-style of the west results in very high resource use as compared to less developed countries. With every unit of energy, mineral or any resource used there is waste generation and pollution in the environment.

A comparison of USA and India can illustrate this point more clearly (Table 6.1).

**Table 6.1. Comparison of consumerism and waste generation**

| Parameter | Percent global values | |
|---|---|---|
| | USA | India |
| Population | 4.7% | 16 % |
| Production of Goods | 21% | 1 % |
| Energy use | 25% | 3 % |
| Pollutants/wastes | 25% | 3 % |
| CFC's Production | 22% | 0.7 % |

The table shows that although the population of India is 3.4 times more than that of U.S.A. its overall energy use and waste generation are less than 1/8th that of USA. Thus more consumerism leads to more waste production

**Consumerism highlights (Paul Ehrlich)**

- On an average, a U.S. citizen consumes 50 times as much as an Indian.
- A U.S. born baby due to high consumerism will damage the planet earth 20-100 times more in a lifetime than a baby born in a poor family of LDC.
- A Japanese with a similar life-style as that of an American causes half the impact on environment. This is due to better technology. By adopting energy efficient and eco-friendly technologies and by following 3'R principle of Reduce, Reuse, Recycle they have minimized the waste generated due to consumerism.

## ENVIRONMENTAL LEGISLATION

India is the first country in the world to have made provisions for the protection and conservation of environment in its constitution. On 5th June, 1972, environment was first discussed as an item of international agenda in the **U.N. Conference on Human Environment** in Stockholm and thereafter **5th June** is celebrated all over the world as **World Environment Day**. Soon after the Stockholm Conference our country took substantive legislative steps for environmental protection. The Wildlife (Protection) Act was passed in 1972, followed by the Water (Prevention and Control of Pollution) Act 1974, the Forest (Conservation) Act, 1980, Air (Prevention and Control of Pollution) Act, 1981 and subsequently the Environment (Protection) Act, 1986.

### Constitutional Provisions

The provisions for environmental protection in the constitution were made within four years of Stockholm Conference, in 1976, through the 42nd amendment as follows :

**Article 48-A** of the constitution provides: *"The state shall endeavour to protect and improve the environment and to safeguard forests and wildlife of the country."*

**Article 51A(g)** provides: *"It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures."*

Thus our constitution includes environmental protection and conservation as one of our fundamental duties.

Some of the important Acts passed by the Government of India are discussed here.

### ■ WILDLIFE (PROTECTION) ACT, 1972

The act, a landmark in the history of wildlife legislation in our country, came into existence in 1972. Wildlife was transferred from State list to concurrent list in 1976, thus giving power to the Central Govt. to enact the legislation.

The **Indian Board of Wildlife (IBWL)** was created in 1952 in our country, which after the enactment of the Wildlife (Protection) Act actively took up the task of setting up wildlife National Parks and sanctuaries. The major activities and provisions in the act can be summed up as follows:

(*i*) It defines the wild-life related terminology.

(*ii*) It provides for the appointment of wildlife advisory Board, Wildlife warden, their powers, duties etc.

(*iii*) Under the Act, comprehensive listing of endangered wild life species was done for the first time and prohibition of hunting of the endangered species was mentioned.

(*iv*) Protection to some endangered plants like Beddome cycad, Blue Vanda, Ladies Slipper Orchid, Pitcher plant etc. is also provided under the Act.

(*v*) The Act provides for setting up of National Parks, Wildlife Sanctuaries etc.

(*vi*) The Act provides for the constitution of Central Zoo Authority.

(*vii*) There is provision for trade and commerce in some wildlife species with license for sale, possession, transfer etc.

(*viii*) The Act imposes a ban on the trade or commerce in scheduled animals.

(*ix*) It provides for legal powers to officers and punishment to offenders.

(*x*) It provides for captive breeding programme for endangered species.

Several Conservation Projects for individual endangered species like lion (1972) Tiger (1973), Crocodile (1974) and Brown antlered Deer (1981) were started under this Act. The Act is adopted by all states in India except J & K, which has it own Act.

Some of the major drawbacks of the Act include mild penalty to offenders, illegal wild life trade in J & K, personal ownership certificate for animal articles like tiger and leopard skins, no coverage of foreign endangered wildlife, pitiable condition of wildlife in mobile zoos and little emphasis on protection of plant genetic resources.

## ■ FOREST (CONSERVATION) ACT, 1980

This act deals with the conservation of forests and related aspects. Except J & K, the act is adopted all over India. The Act covers under it all types of forests including reserved forests, protected forests or any forested land irrespective of its ownership.

The salient features of the Act are as follows:

(*i*) The State Govt. has been empowered under this Act to use the forests only for forestry purposes. If at all it wants to use it in any other way, it has to take prior approval of central Government, after

which it can pass orders for declaring some part of reserve forest for non-forest purposes (e.g mining) or for clearing some naturally growing trees and replacing them by economically important trees (reforestation).

(*ii*) It makes provision for conservation of all types of forests and for this purpose there is an Advisory committee which recommends funding for it to the Central Government.

(*iii*) Any illegal non-forest activity within a forest area can be immediately stopped under this Act.

Non-forest activities include clearing of forest land for cultivation of any type of plants/crops or any other purpose (except re-afforestation). However, some construction work in the forest for wildlife or forest management is exempted from non-forest activity (e.g. fencing, making water-holes, trench, pipelines, check posts, wireless communication etc.)

### 1992 Amendment in the Forest Act

- In 1992, some amendment was made in the Act which made provisions for allowing some non-forest activities in forests, without cutting trees or limited cutting with prior approval of Central Govt. These activities are setting of transmission lines, seismic surveys, exploration, drilling and hydroelectric projects. The last activity involves large scale destruction of forest, for which prior approval of the Centre is necessary.
- Wildlife sanctuaries, National Parks etc. are totally prohibited for any exploration or survey under this Act without prior approval of Central Govt. even if no tree-felling is involved.
- Cultivation of tea, coffee, spices, rubber and plants which are cash-crops, are included under non-forestry activity and not allowed in reserve forests.
- Even cultivation of fruit-bearing trees, oil-yielding plants or plants of medicinal value in forest area need to be first approved by the Central Govt. This is because newly introduced species in the forest area may cause an imbalance in the ecology of the forest. If the species to be planted is a native species, then no prior clearance is required.
- Tusser cultivation (a type of silk-yielding insect) in forest areas by tribals as a means of their livelihood is treated as a forestry activity as long as it does not involve some specific host tree

like Asan or Arjun. This is done in order to discourage monoculture practices in the forests which are otherwise rich in biodiversity.

- Plantation of mulberry for rearing silkworm is considered a non-forest activity. The reason is same as described above.
- Mining is a non-forestry activity and prior approval of Central Govt. is mandatory. The Supreme Court in a case T.N. Godavarman Thirumulkpad Vs. Union of India (1997) directed all on-going mining activity to be ceased immediately in any forest area of India if it had not got prior approval of Central government.
- Removal of stones, bajri, boulder etc from river-beds located within the forest area fall under non-forest activity.
- Any proposal sent to central govt. for non-forest activity must have a cost-benefit analysis and Environmental Impact statement (EIS) of the proposed activity with reference to its ecological and socio-economic impacts.

Thus, the Forests (Conservation) Act has made ample provisions for conservation and protection of forests and prevent deforestation.

## ■ WATER (PREVENTION AND CONTROL OF POLLUTION) ACT, 1974

It provides for maintaining and restoring the wholesomeness of water by preventing and controlling its pollution. Pollution is defined as *such contamination of water, or such alteration of the physical, chemical or biological properties of water, or such discharge as is likely to cause a nuisance or render the water harmful or injurious to public health and safety or harmful for any other use or to aquatic plants and other organisms or animal life.*

The definition of water pollution has thus encompassed the entire probable agents in water that may cause any harm or have a potential to harm any kind of life in any way.

The salient features and provisions of the Act are summed up as follows:

(*i*) It provides for maintenance and restoration of quality of all types of surface and ground water.

(*ii*) It provides for the establishment of Central and State Boards for pollution control.

(*iii*) It confers them with powers and functions to control pollution.

The Central and State Pollution Control Boards are widely represented and are given comprehensive powers to advise, coordinate and provide technical assistance for prevention and control of pollution of water.

(*iv*) The Act has provisions for funds, budgets, accounts and audit of the Central and State Pollution Control Boards.

(*v*) The Act makes provisions for various penalties for the defaulters and procedure for the same.

The main regulatory bodies are the Pollution Control Boards, which have been, conferred the following duties and powers:

**Central Pollution Control Board (CPCB):**

- It advises the central govt. in matters related to prevention and control of water pollution.
- Coordinates the activities of State Pollution Control Boards and provides them technical assistance and guidance.
- Organizes training programs for prevention and control of pollution.
- Organizes comprehensive programs on pollution related issues through mass media.
- Collects, compiles and publishes technical and statistical data related to pollution.
- Prepares manuals for treatment and disposal of sewage and trade effluents.
- Lays down standards for water quality parameters.
- Plans nation-wide programs for prevention, control or abatement of pollution.
- Establishes and recognizes laboratories for analysis of water, sewage or trade effluent sample.

The **State Pollution Control Boards** also have similar functions to be executed at state level and are governed by the directions of CPCB.

- The Board advises the state govt. with respect to the location of any industry that might pollute a stream or a well.
- It lays down standards for effluents and is empowered to take samples from any stream, well or trade effluent or sewage passing through an industry.
- The State Board is empowered to take legal samples of trade effluent in accordance with the procedure laid down in the Act. The sample taken in the presence of the occupier or his agent is divided into two parts, sealed, signed by both parties

and sent for analysis to some recognized lab. If the samples do not conform to the prescribed water quality standards (crossing maximum permissible limits), then 'consent' is refused to the unit.

- Every industry has to obtain consent from the Board (granted for a fixed duration) by applying on a prescribed Proforma providing all technical details, along with a prescribed fee following which analysis of the effluent is carried out.
- The Board suggests efficient methods for utilization, treatment and disposal of trade effluents.

The Act has made detailed provisions regarding the power of the Boards to obtain information, take trade samples, restrict new outlets, restrict expansion, enter and inspect the units and sanction or refuse consent to the industry after effluent analysis.

While development is necessary, it is all the more important to prevent pollution, which can jeopardize the lives of the people. Installation and proper functioning of effluent treatment plants (ETP) in all polluting industries is a must for checking pollution of water and land. Despite certain weaknesses in the Act, the Water Act has ample provisions for preventing and controlling water pollution through legal measures.

## ■ THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

Salient features of the act are as follows:

(*i*) The Act provides for prevention, control and abatement of air pollution.

(*ii*) In the Act, *air pollution has been defined as the presence of any solid, liquid or gaseous substance (including noise) in the atmosphere in such concentration as may be or tend to be harmful to human beings or any other living creatures or plants or property or environment.*

(*iii*) Noise pollution has been inserted as pollution in the Act in 1987.

(*iv*) Pollution control boards at the central or state level have the regulatory authority to implement the Air Act. Just parallel to the functions related to Water (Prevention and Control of Pollution) Act, the boards performs similar functions related to improvement of air quality. The boards have to check whether or not the industry strictly follows the norms or standards laid down by the Board under section 17, regarding the discharge of emission of any air pollutant. Based upon analysis report consent is granted or refused to the industry.

(*v*) Just like the Water Act, the Air Act has provisions for defining the constitution, powers and function of Pollution Control Boards, funds, accounts, audit, penalties and procedures.

(*vi*) Section 20 of the Act has provision for ensuring emission standards from automobiles. Based upon it, the state govt. is empowered to issue instructions to the authority incharge of registration of motor vehicles (under Motor Vehicles Act, 1939) that is bound to comply with such instructions.

(*vii*) As per Section 19, in consultation with the State Pollution Control Board, the state government may declare an area within the state as **"air pollution control area"** and can prohibit the use of any fuel other than approved fuel in the area causing air pollution. No person shall, without prior consent of State Board operate or establish any industrial unit in the "air pollution control area".

The Water and Air Acts have also made special provisions for appeals. Under Section 28 of Water Act and Section 31 of Air Act, a provision for appeals has been made. An **Appellate Authority** consisting of a single person or three persons appointed by the Head of the State, Governor is constituted to hear such appeals as filed by some aggrieved party (industry) due to some order made by the State Board within 30 days of passing the orders.

The Appellate Authority after giving the appellant and the State Board an opportunity of being heard, disposes off the appeal as expeditiously as possible.

## ■ THE ENVIRONMENT (PROTECTION) ACT, 1986

The Act came into force on Nov. 19, 1986, the birth anniversary of our Late Prime Minister Indira Gandhi, who was a pioneer of environmental protection issues in our country. The Act extends to whole of India. Some terms related to environment have been described as follows in the Act:

(*i*) **Environment** includes water, air and land and the inter-relationships that exists among and between them and human beings, all other living organisms and property.

(*ii*) **Environmental pollution** means the presence of any solid, liquid or gaseous substance present in such concentration, as may be, or tend to be, injurious to environment.

(*iii*) **Hazardous Substance** means any substance or preparation which by its physico-chemical properties or handling is liable to cause harm to human beings, other living organisms, property or environment.

The Act has given powers to the Central Government to take measures to protect and improve environment while the state governments coordinate the actions. The most important functions of Central Govt. under this Act include setting up of:

(*a*) The standards of quality of air, water or soil for various areas and purposes.

(*b*) The maximum permissible limits of concentration of various environmental pollutants (including noise) for different areas.

(*c*) The procedures and safeguards for the handling of hazardous substances.

(*d*) The prohibition and restrictions on the handling of hazardous substances in different areas.

(*e*) The prohibition and restriction on the location of industries and to carry on process and operations in different areas.

(*f*) The procedures and safeguards for the prevention of accidents which may cause environmental pollution and providing for remedial measures for such accidents.

The power of entry and inspection, power to take sample etc. under this Act lies with the Central Government or any officer empowered by it.

For the purpose of protecting and improving the quality of the environment and preventing and abating pollution, standards have been specified under Schedule I- IV of Environment (Protection) Rules, 1986 for emission of gaseous pollutants and discharge of effluents/waste water from industries. These standards vary from industry to industry and also vary with the medium into which the effluent in discharged or the area of emission. For instance, the maximum permissible limits of B.O.D. (Biochemical Oxygen Demand) of the waste water is 30 ppm if it is discharged into inland waters, 350 ppm if discharged into a public sewer and 100 ppm, if discharged onto land or coastal region. Likewise, emission standards vary in residential, sensitive and industrial area. Naturally the standards for sensitive areas like hospitals are more stringent. It is the duty of the Pollution Control Board to check whether the industries are following the prescribed norms or not.

Under the **Environmental (Protection) Rules, 1986** the State Pollution Control Boards have to follow the guidelines provided under Schedule VI, some of which are as follows:

(*a*) They have to advise the Industries for treating the waste water and gases with the best available technology to achieve the prescribed standards.

(*b*) The industries have to be encouraged for recycling and reusing the wastes.

(*c*) They have to encourage the industries for recovery of biogas, energy and reusable materials.

(*d*) While permitting the discharge of effluents and emissions into the environment, the State Boards have to take into account the assimilative capacity of the receiving water body.

(*e*) The Central and State Boards have to emphasize on the implementation of clean technologies by the industries in order to increase fuel efficiency and reduce the generation of environmental pollutants.

Under the Environment (Protection) Rules, 1986 an amendment was made in 1994 for Environmental Impact Assessment (EIA) of Various Development Projects. There are 29 types of projects listed under Schedule I of the rule which require clearance from the Central Government before establishing.

Others require clearance from the State Pollution Control Board, when the proposed project or expansion activity is going to cause pollution load exceeding the existing levels. The project proponent has to provide EIA report, risk analysis report, NOC from State Pollution Control Board, Commitment regarding availability of water and electricity, Summary of project report/feasibility report, filled in a questionnaire for environmental appraisal of the project and comprehensive rehabilitation plan, if more than 1000 people are likely to be displaced due to the project.

Under the Environment (Protection) Act, 1986 the Central Government also made the Hazardous Wastes (Management and Handling) Rules, 1989. Under these rules, it is the responsibility of the occupier to take all practical steps to ensure that such wastes are properly handled and disposed off without any adverse effects. There are 18 Hazardous Waste categories recognized under this rule and there are guidelines for their proper handling, storage, treatment, transport and disposal which should be strictly followed by the owner.

The Environment (Protection) Act, 1986 has also made provision for environmental Audit as a means of checking whether or not a company is complying with the environmental laws and regulations. Thus, ample provisions have been made in our country through law for improving the quality of our environment.

## ■ ENFORCEMENT OF ENVIRONMENTAL LEGISLATION—MAJOR ISSUES

We have seen that there are a number of important environmental laws in the form of Acts for safeguarding our environmental quality. But inspite of these acts, we find that we are not able to achieve the target of bringing 33% of our land cover under forests. Still we are losing our wild life. The rivers have been turned into open sewers in many places and the air in our big cities is badly polluted. The status of environment shows that there are drawbacks in environmental legislations and problems in their effective implementation.

Let us examine some important issues related to our acts:

(*a*) **Drawbacks of the Wildlife (Protection) Act, (1972)**

- It seems as if the Act has been enacted just as a fallout of Stockholm Conference held in 1972 and it has not included any locally evolved conservation measures.
- The ownership certificates for animal articles (tiger, leopard skins etc.) are permissible which very often serve as a tool for illegal trading.
- The wildlife traders in Jammu and Kashmir easily get illegal furs and skins from other states which after making caps, belts etc. are sold or smuggled to other countries. This is so happening because J & K has its own Wildlife Act and it does not follow the Central Wild Life Act. Moreover, hunting and trading of several endangered species prohibited in other states are allowed in J & K, thereby opening avenues for illegal trading in such animals and articles.
- The offender of the Act is not subject to very harsh penalties. It is just upto 3 years imprisonment or a fine of Rs. 25,000 or both.

(*b*) **Drawbacks of the Forest (Conservation) Act, 1980:** This Act has inherited the exploitative and consumerist elements from the Forest laws of British period. It has just transferred the powers from state to centre, to decide the conversion of reserve forest lands to non-forest areas. Thus power has been centralized at the top. At the same time, the local communities have been completely kept out from the decision-making process regarding the nature of use of forest area. Very often, the tribals who lived in the forest and were totally dependent on forests retaliate when stopped from taking any resources from there and start

criminal activities including smuggling, killing etc. The Act has failed to attract public support because it has infringed upon the human rights of the poor native people. They argue that the law is concerned about protecting the trees, birds and animals, but is treating the poor people as marginal. ***Very poor community participation in the Act remains one of the major drawbacks which affects proper execution of the Act.*** The forest-dwelling tribal communities have a rich knowledge about the forest resources, their importance and conservation. But, their role and contribution is neither acknowledged nor honoured.

Efforts are now being made to make up for the gaps in laws by introducing the principles of Public trust or Human rights Protection.

## DRAWBACKS OF POLLUTION RELATED ACTS

- The power and authority has been given to central government with little delegation of power to state government. Excessive centralization very often hinders efficient execution of the provisions of the Acts in the states. Illegal mining is taking place in many forest areas. In Rajasthan alone, about 14000 cases of illegal mining have been reported. It becomes more difficult to check such activities at the central level.
- The provision of penalties in the Act is very insignificant as compared to the damage caused by the big industries due to pollution. The penalty is much less than the cost of the treatment/ pollution control equipments. This always gives a loose rope to the industries.
- The Act has not included the "right to information" for the citizens. This greatly restricts the involvement or participation of the general public.
- The Environment (Protection) Act, 1986 regarded as an umbrella Act, encompassing the earlier two Acts often seems superfluous due to overlapping areas of jurisdiction. For instance Section 24 (2) of the new Act has made a provision that if the offender is punishable under the other Acts like Water Act or Air Act also, then he may be considered under their provisions. Interestingly, the penalty under the older two Acts is much lighter than the new Act. So the offender easily gets away with a lighter punishment.
- Under Section 19, a person cannot directly file a petition in the court on a question of environment and has to give a notice of minimum 60 days to the central government. In case

no action is taken by the latter, then alone the person can file a petition which certainly delays the remedial action.

- Litigation, particularly related to environment is very expensive, tedious and difficult since it involves expert testimony, technical knowledge of the issues and terminologies, technical understanding of the unit process, lengthy prosecutions etc.
- The State Boards very often lack adequate funds and expertise to pursue their objectives.
- A tendency to seek to exercise gentle pressure on the polluter and out of the court settlements usually hinder the implementation of legal measures.
- For small units it is very expensive to install Effluent Treatment Plant (ETP) or Air pollution control devices and sometimes they have no other option but to close the unit. The Act should make some provision for providing subsidies for installing treatment plants or common effluent treatment plants for several small units.
- The pollution control laws are not backed by sound policy pronouncements or guiding principles.
- The position of chairman of the boards is usually occupied by political appointee. Hence it is difficult to keep political interference at bay.
- The policy statement of the Ministry of Environment and Forests (1992) of involving public in decision-making and facilitating public monitoring of environmental issues has mostly remained on paper.

Environmental policies and laws need to be aimed at democratic decentralization of power, community-state partnership, administrative transparency and accountability and more stringent penalties to the offender. There is also a need for environmental law education and capacity building in environmental issues for managers.

## ■ PUBLIC ENVIRONMENTAL AWARENESS

Public awareness about environment is at a stage of infancy. Of late, some awareness has taken place related to environmental degradation, pollution etc. but incomplete knowledge and information and ignorance about many aspects has often led to misconceptions.

Development has paved the path for rise in the levels or standards of living but it has simultaneously led to serious environmental disasters.

Issues related to environment have often been branded as anti-development. The wisdom lies in maintaining a balance between our needs and supplies so that the delicate ecological balance is not disrupted.

Some of the main reasons responsible for widespread environmental ignorance can be summed up as follows:

(*i*) Our courses in Science, technology, economics etc. have so far failed to integrate the knowledge in environmental aspects as an essential component of the curriculum.

(*ii*) Our planners, decision-makers, politicians and administrators have not been trained so as to consider the environmental aspects associated with their plans.

(*iii*) In a zeal to go ahead with some ambitious development projects, quite often there is purposeful concealment of information about environmental aspects.

(*iv*) There is greater consideration of economic gains and issues related to eliminating poverty by providing employment that overshadows the basic environmental issues.

### Methods to Propagate Environmental Awareness

Environmental awareness needs to be created through formal and informal education to all sections of the society. Everyone needs to understand it because 'environment belongs to all' and 'every individual matters' when it comes to conservation and protection of environment.'

Various stages and methods that can be useful for raising environmental awareness in different sections of the society are as follows:

(*i*) **Among students through education:** Environmental education must be imparted to the students right from the childhood stage. It is a welcome step that now all over the country we are introducing environmental studies as a subject at all stages including school and college level, following the directives of the Supreme Court.

(*ii*) **Among the Masses through mass-media:** Media can play an important role to educate the masses on environmental issues through articles, environmental rallies, plantation campaigns, street plays, real eco-disaster stories and success stories of conservation efforts. TV serials like *Virasat, Race to save the Planet, Heads and Tails, Terra-view, Captain planet* and the like have been effective in propagating the seeds of environmental awareness amongst the viewers of all age groups. (Plate VI, VII)

Plate VI. Awareness through Environmental rally, small children can be very effective in spreading the message of environmental protection among general public through their spontaneous love for nature.

Plate VII. Tree plantation compaigns serve as the most effective environmental conservation efforts involving local people. Sh. Sunderlal Bahuguna, the Chipko movement leader, planting a sapling.

(*iii*) **Among the planners, decision-makers and leaders:** Since this elite section of the society plays the most important role in shaping the future of the society, it is very important to give them the necessary orientation and training through specially organized workshops and training programmes.

Publication of environment - related resource material in the form of pamphlets or booklets published by Ministry of Environment & Forests can also help in keeping this section abreast of the latest developments in the field.

### Role of Non-Government Organisations (NGO's)

Voluntary organizations can help by advising the government about some local environmental issues and at the same time interacting at the grass-root levels. They can act as an effective and viable link between the two. They can act both as an **'action group'** or a **'pressure group'**. They can be very effective in organizing public movements for the protection of environment through creation of awareness.

The **"Chipko Movement"** for conservation of trees by **Dasholi Gram Swarajya Mandal** in Gopeshwar or the **"Narmada Bachao Andolan"** organized by **Kalpavriksh**, are some of the instances where NGO's have played a landmark role in the society for conservation of environment.

The **Bombay Natural History Society (BNHS)**, the **World Wide Fund for Nature - India (WWF, India) Kerala Sastra Sahitya Parishad**, **Centre for Science and Environment (CSE)** and many others are playing a significant role in creating environmental awareness through research as well as extension work. The recent report by CSE on more than permissible limits of pesticides in the cola drinks sensitized the people all over the country.

Before we can all take up the task of environmental protection and conservation, we have to be environmentally educated and aware. It is aptly said ***"If you want to act green, first think green."***

## QUESTIONS

1. What do you mean by sustainable development ? What are the major measures to attain sustainability ?
2. Why is urban requirement of energy more than rural requirement ?
3. Discuss the measures to conserve water.
4. What is rainwater harvesting ? What are the purposes served by it ?

5. What is a watershed ? Critically discuss the objectives and practices of watershed management.
6. What do we mean by 'environment refugees' or 'oustees' ? What are the major causes for displacement of native tribal people ? Discuss in the light of some case studies.
7. What are the major issues and problems related to rehabilitation of the displaced tribals ? Discuss in the light of some case study.
8. Critically discuss the anthropocentric and ecocentric world view. Which world view appeals to you more and why ?
9. What are greenhouse gases and greenhouse effect ? Discuss the potential and contribution of these gases to global warming phenomenon.
10. What are the major implications of enhanced global warming ?
11. What is meant by acid rain ? How does it form ? In which regions of India acid rain has been recorded ?
12. What are the major impacts of acid rain and how can we control it ?
13. Discuss the natural formation and occurrence of ozone in the stratosphere.
14. Which are the agents responsible for ozone depletion ?
15. Write a critical note on Nuclear holocaust.
16. Discuss various measures for wasteland reclamation.
17. "Population, consumerism and waste production are interrelated"—Comment.
18. Discuss the salient features of (*a*) Wildlife (Protection) Act, 1972 (*b*) Forest (Conservation Act), 1980.
19. How do you define pollution as per Water (Prevention and Control of Pollution) Act, 1974 ? What are the salient features of the Act ?
20. Who has the authority to declare an area as "air pollution control area" in a state under the Air (Prevention and Control of Pollution) Act, 1981 ? When was noise inserted in this act ?
21. Why do we refer to Environmental Protection Act, 1986 as an Umbrella Act. Discuss the Major Environmental Protection Rules, 1986.
22. What are the major limitations to successful implementation of our enviornmental legislation ?
23. What are the different methods to propagate environmental awareness in the society ?

Unit

# 7 Human Population and the Environment

## ■ POPULATION GROWTH

In 1800, the earth was home to about 1 billion people. The dramatic way in which global human population grew thereafter is shown in Fig. 7.1. It took about thirty nine thousand years of human history to reach 1 billion, 130 years to reach the second billion, 45 years to reach 4 billion and the next doubling is likely within a span of a few decades. We have already crossed 6 billion and may reach 11 billion by 2045 as per the World Bank estimates.

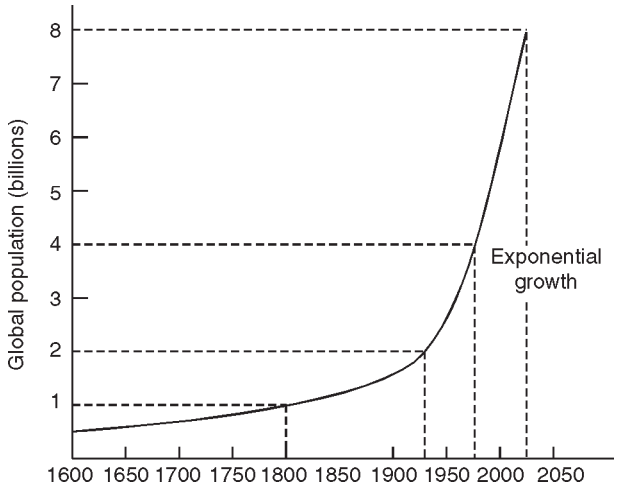



Fig. 7.1. Global population growth trends in the last four centuries.

Let us look at the reasons of this trend of human population growth. In the beginning of human civilization, during the Stone Age, population was quite stable. Environmental conditions were hostile and humans had not yet developed adequate artificial means for adaptations to these stresses. Droughts and outbreak of diseases used to be quite common leading to mass deaths. The 14th century A.D.

experienced large scale mortality due to bubonic plague when about 50% of people in Asia and Europe died due to the disease.

With scientific and technological advancement, life expectancy of humans improved. People started living in definite settlements leading a more stable life with better sanitation, food and medical facilities. Victory over famine-related deaths and infant mortality became instrumental for a rapid increase in population size. In agriculture based societies children were considered as economic assets who would help the parents in the fields and that is why in the developing countries, population growth climbed to unthought-of heights, at the rate of 3-4% per year, accounting for about 90-95% of total population growth of the world in the last 50 years.

## ■ POPULATION CHARACTERISTICS AND VARIATIONS AMONG NATIONS

***Exponential growth:*** When a quantity increases by a constant amount per unit time *e.g.* 1, 3, 5, 7 etc. it is called linear growth. But, when it increases by a fixed percentage it is known as exponential growth *e.g.* 10, $10^2$, $10^3$, $10^4$, or 2, 4, 8, 16, 32 etc. Population growth takes place exponentially and that explains the dramatic increase in global population in the past 150 years.

***Doubling time:*** The time needed for a population to double its size at a constant annual rate is known as doubling time. It is calculated as follows:

Td = 70/r

where Td = Doubling time in years

r = annual growth rate

If a nation has 2% annual growth rate, its population will double in 35 years.

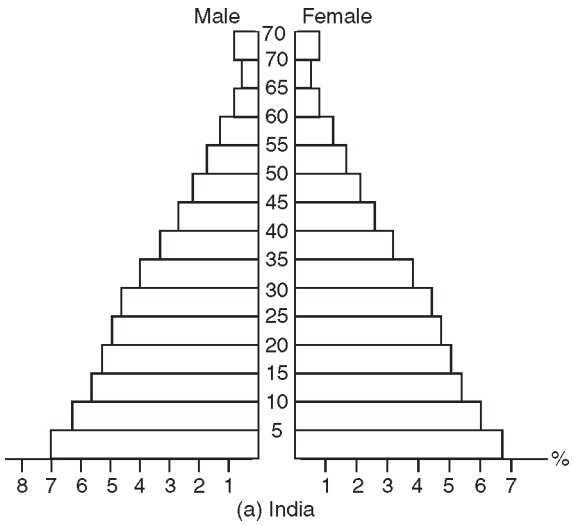
***Total Fertility rates (TFR) :*** It is one of the key measures of a nation's population growth. TFR is defined as the average number of children that would be born to a woman in her lifetime if the age specific birth rates remain constant. The value of TFR varies from 1.9 in developed nations to 4.7 in developing nations. In 1950's the TFR has been 6.1. However, due to changes in cultural and technological set up of societies and government policies the TFR has come down which is a welcome change.

***Infant mortality rate:*** It is an important parameter affecting future growth of a population. It is the percentage of infants died out of those born in a year. Although this rate has declined in the last 50 years, but the pattern differs widely in developed and developing countries.

***Replacement level:*** This is an important concept in population dynamics or demography. Two parents bearing two children will be replaced by their offspring. But, due to infant mortality this replacement level is usually changed. For developing nations, where infant mortality is high and life expectancy is low, the replacement level is approx 2.7, whereas in developed nations it is 2.1.

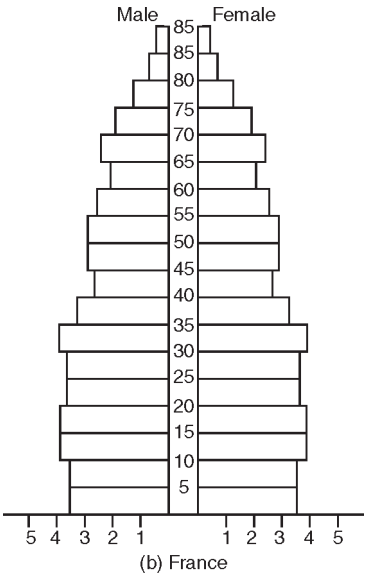
***Age Structure:*** Age structure of population of a nation can be represented by age pyramids, based upon people belonging to different age classes like pre-reproductive (0-14 years), reproductive (15-44 years) and post reproductive (45 years and above). We get three types of age pyramids:

(*a*) **Pyramid shaped**: Here the very young population is more, making a broad base and old people are less. This type indicates growing population. India, Bangladesh, Ethiopia, Nigeria are examples of this type. The large number of individuals in very young age will soon enter into reproductive age, thus causing an increase in population, whereas less number of people in old age indicate less loss of population due to death (Fig. 7.2(*a*)).



(a) India

(*b*) **Bell shaped:** It occurs in countries like France, USA and Canada where birth rates have in the past one or two decades declined resulting in people of almost equal number in age group 0-35 years. So in the next 10 years, the people entering into reproductive age group is not going to change much and such age-pyramids indicate stable populations (Fig 7.2(*b*)).




(*c*) **Urn shaped:** Here number of individuals in very young class is smaller than the middle reproductive age class. In the next 10 years the number in reproductive age class will thus become less than before resulting in a decline of population growth. Germany, Italy, Hungary, Sweden and Japan are examples of this type (Fig. 7.2(*c*)).

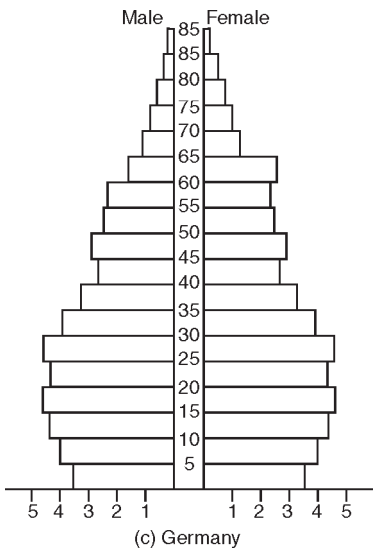



Fig. 7.2. Age pyramids (*a*) Pyramid shaped expanding population—India, (*b*) Bell-shaped stable population—France, (*c*) Urn-shaped declining population—Germany.

(**Source:** UN Demography year book, 2000)

The TFR, age structure, infant mortality and replacement level are all important parameters determining population growth. But population will not stop growing even when all couples have only 2 children.

## CASE STUDIES

- Ethiopia is a developing nation with a pyramid shaped age structure indicating expanding population. Its TFR is 6.9 presently. Even if it aims to reach the replacement level by the year 2050, its population that is 57 million now would rise to 225 million by 2050 when TFR becomes 2.1 and continue growing until it levels off, 100 years later, at 370 million.
- Population growth is also affected due to AIDS in the HIV-prevalent countries mainly in Africa. The earlier population projections of UN are now found to be reduced by 8% in the seriously HIV-affected countries i.e. Mali, Rwanda, Uganda and Zambia. In Zimbabwe, HIV affects a quarter of the population aged between 15-49 yrs. In Botswana, 2/3rd of the 15 year olds are predicted to die of AIDS before reaching 50 years of age. About 30% of adult population in many African countries is HIV-positive. This has drastically reduced life expectancy in these countries.

***Zero population growth (ZPG):*** When birth plus immigration in a population are just equal to deaths plus emigration, it is said to be zero population growth.

***Male-Female ratio:*** The ratio of boys and girls should be fairly balanced in a society to flourish. However, due to female infanticides and gender-based abortions, the ratio has been upset in many countries including India. In China, the ratio of boys to girls became 140:100 in many regions which led to scarcity of brides.

***Life expectancy:*** It is the average age that a newborn infant is expected to attain in a given country. The average life expectancy, over the globe, has risen from 40 to 65.5 years over the past century. In India, life expectancy of males and females was only 22.6 years and 23.3 years, respectively in 1900. In the last 100 years improved medical facilities and technological advancement has increased the life expectancy to 60.3 years and 60.5 years, respectively for the Indian males and females. In Japan and Sweden, life expectancy is quite higher, being 82.1-84.2 for females and 77-77.4 for males, respectively.

***Demographic transition:*** Population growth is usually related to economic development. There occurs a typical fall in death rates and

birth rates due to improved living conditions leading to low population growth, a phenomenon called demographic transition.

It is associated with ubranisation and growth and occurs in four phases:

(*a*) **Pre industrial phase** characterized by high growth and death rates and net population growth is low.

(*b*) **Transitional phase** that occurs with the advent of industrialization providing better hygiene and medical facilities and adequate food, thereby reducing deaths. Birth rates, however, remain high and the population shows 2.5-3% growth rate.

(*c*) **Industrial phase** while there is a fall in birth rates thereby lowering growth rate.

(*d*) **Post industrial phase** during which zero population growth is achieved.

Demographic transition is already observed in most developing nations. As a result of demographic transition the developed nations are now growing at a rate of about 0.5% with a doubling time of 118 years. However, the matter of concern is that more than 90% of the global population is concentrated in developing nations which have a growth rate a little more than 2%, and a doubling time of less than 35 years.

## ■ POPULATION EXPLOSION

There has been a dramatic reduction in the doubling time of the global human population, as we have already discussed. In the 20th century, human population has grown much faster than ever before. Between 1950-1990, in just 40 years the population crossed 5 billion mark with current addition of about 92 million every year, or so to say, adding a new Mexico every year. In the year 2000, the world population was 6.3 billion and it is predicted to grow four times in the next 100 years. This unprecedented growth of human population at an alarming rate is referred to as **population explosion**.

**The Indian Scenario:** India is the second most populous country of the world with 1 billion people. If the current growth rates continue, it will have 1.63 billion people by 2050 and will become the most populous country surpassing China. So we are heading for very serious ramifications of the population explosion problem. Do we have the resources and provisions for feeding, housing, educating and employing all those people being added every year? If we look at the population statistics

of our country we find that in just 35 years after independence we added another India in terms of population. On 11th May, 2000 we became 1 billion and now we can say that every 6th person in this world is an Indian.

**The Population Clock**

Every second, on an average 4-5 children are born and 2 people die, thus resulting in net gain of nearly 2.5 person every second. This means that every hour we are growing by about 9000 and everyday by about 2,14,000.

Population explosion is causing severe resource depletion and environmental degradation. Our resources like land, water, fossil fuels, minerals etc. are limited and due to over exploitation these resources are getting exhausted. Even many of the renewable resources like forests, grasslands etc. are under tremendous pressure. Industrial and economic growth are raising our quality of life but adding toxic pollutants into the air, water and soil. As a result, the ecological life-support systems are getting jeopardized. There is a fierce debate on this issue as to whether we should immediately reduce fertility rates through worldwide birth control programs in order to stabilize or even shrink the population or whether human beings will devise new technologies for alternate resources, so that the problem of crossing the carrying capacity of the earth will never actually come.

There are two very important views on population growth which need a mention here:

**Malthusian Theory:** According to Malthus, human populations tend to grow at an exponential or compound rate whereas food production increases very slowly or remains stable. Therefore, starvation, poverty, disease, crime and misery are invariably associated with population explosion. He believes "positive checks" like famines, disease outbreak and violence as well as "preventive checks" like birth control need to stabilize population growth.

**Marxian Theory:** According to Karl Marx, population growth is a symptom rather than the cause of poverty, resource depletion, pollution and other social ills. He believed that social exploitation and oppression of the less privileged people leads to poverty, overcrowding, unemployment, environmental degradation that in turn, causes over population.

A compromise between the two views is required because all these factors seem to be interdependent and interrelated. Equity and social justice to all, allowing everyone to enjoy a good standard of living is the need of the hour that can voluntarily help in achieving a stabilized global population.

### Family Welfare Programmes

Population explosion is like a time bomb that must be diffused well in time. The population must be kept much below the carrying capacity and stabilized, so that the aftermath of explosion could be avoided.

It is not precisely known as to how long can we continue our exponential growth in population and resource use without suffering overshoot or dieback. We are getting warning signals that if not controlled, the increasing population is going to deplete all the resources beyond their regeneration capacity. A catastrophic doomsday model warns us that the earth cannot sustain more than two more doublings *i.e.* 25 billion.

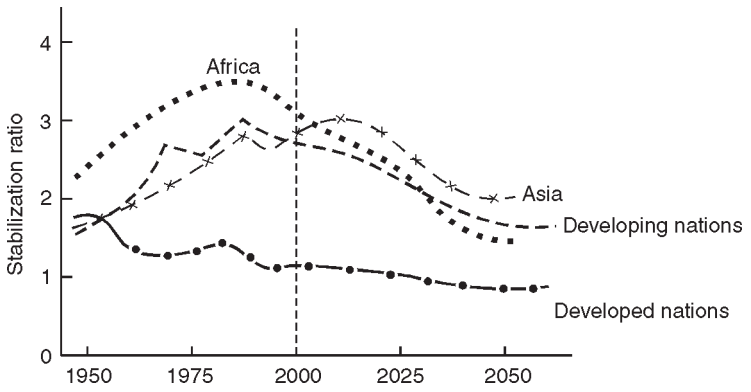



Fig. 7.3. Stabilization ratio of developing & developed nations, Africa and Asia. A ratio of 1 achieved in developed nations around 2000 indicates zero population growth in developed nations while Africa is presently having the highest ratio.

The United Nations projections about **population stabilization** of developed and developing nations and that of Asia are shown in Fig. 7.3. The ratio is derived by dividing crude birth rate by crude death rate. As evident, developed nations have already achieved a stabilization ratio of 1 around the year 2000, which is more or less stabilized indicating zero population growth. Developing nations including Asia, on the other hand, is yet having a high stabilization ratio nearing 3, which is however, on a decline and is expected to lower down substantially by

2025. Stabilization in developing nations is possible only through various family welfare programmes.

**The Kerala Model (A case study)**

Kerala has earned the distinction of having lowest birth rates among all the states of India. The main parameters deciding the effectivity of this model depends upon the age of marriage for women at 21 years, as against and Indian average of 18 years, female literacy of 53% against Indian average of 13%, greater emphasis on primary education with 60% budget provision for the same, as against 50% in many other states, better public distribution system of food among 97% of population, better medical facilities in rural areas and greater success of family planning programmes. The Kerala Model has its own success story emphasizing the effectivity of social justice approach for family planning.

## ■ FAMILY PLANNING

Family planning allows couples to decide their family size and also the time spacing of their offspring. Almost every culture in the past used to practise some traditional fertility control methods through some traditions, taboos and folk medicine.

Modern science has provided several birth control techniques including mechanical barriers, surgical methods, chemical pills and physical barriers to implantation. More than a hundred contraceptive methods are on trial. The **United Nations Family Planning Agency** provides funds to 135 countries. Many of these countries include abortion as a part of the population control programme which very often encourages female infanticide thereby disturbing the optimal male: female ratio in a society. The birth control programmes have often faced strong opposition from religious groups.

Nonetheless, **World Health Orgaization (WHO)** estimates that today about 50 percent of the worlds' married couples adopt some family planning measures as compared to just 10% about 30 years back. Still some 300 million couples do not have access to family planning.

### The Indian Context

India started the family planning programme in 1952 while its population was nearly 400 million. In 1970's, forced family planning campaign by the Government resulted in a turmoil all over the country.

In 1978, the government raised the legal minimum age of marriage from 18 to 21 for men and 15 to 18 years for women. Even in 1981 census no drop in population growth was observed. Since then funding for family planning programmes has been increased further.

Unable to reach a consensus regarding population policy, the state governments in 2000 were allowed to adopt their own approach. In Kerala, the population has been stabilized with a focus on social justice as already discussed. It is now comparable to many industrialized nations including USA and it has proved that wealth is not a pre-requisite for zero population growth. Andhra Pradesh has also just achieved the target of ZPG in 2001, but it has been done with a different approach. The poor class was encouraged to be sterilized after two children by paying cash incentives, better land, housing, wells and subsidized loans. In contrast, Bihar and U.P. have showed increase in their growth rates (more than 2.5%).

Successful family planning programs need significant societal changes including social, educational and economic status for women, social security, political stability, proper awareness and confidence building alongwith accessibility and effectivity of the birth control measures.

## ■ ENVIRONMENT AND HUMAN HEALTH

In general terms a physically fit person not suffering from any disease is called a healthy person. However, there are many other dimensions associated with the state of being healthy. According to World Health Organisation (WHO) health is **"a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity".** Human health is influenced by many factors like nutritional, biological, chemical or psychological. These factors may cause harmful changes in the body's conditions called disease.

**Infectious organisms:** Disease causing organisms pose greater environmental threats to health, more severely in the developing countries especially the tropical ones. High temperature and moisture along with malnutrition help many diseases to spread in these countries. Microbes especially bacteria can cause food poisoning by producing toxins in the contaminated food. Some moulds grow on food and produce poisonous toxins.

Infectious organisms can also cause respiratory diseases (pneumonia, tuberculosis, influenza etc.) and gastrointestinal diseases (diarrhoea, dysentery, cholera etc.).

There are various types of parasites that cause diseases like malaria, schistosomiasis, filariasis etc. Most of these infections take place when the environmental conditions are unclean and unhygienic.

**Chemicals:** A large number of chemicals are introduced in the environment by anthropogenic activities. Industrial effluents containing various chemicals are of major concern. Chemicals can be divided into two categories i.e. hazardous and toxic chemicals. Hazardous are the dangerous chemicals like explosives, inflammable chemicals etc. Toxic chemicals (**toxins**) are poisonous chemicals which kill cells and can cause death. Many other chemicals can cause cancer (**carcinogenic**), affect genetic material (DNA) in cells (**mutagenic**) or cause abnormalities during embryonic growth and development (**teratogenic**), while there are others that affect nervous system (**neurotoxins**) and the reproductive system. Some of the pesticides and other industrial pollutants may act as hormone analogs in humans and other species. These environmental hormones affect reproduction, development and cause various types of ailments including tumors.

Many chemicals like DDT and other chlorinated pesticides bioaccumulate in food-chain and show deleterious effects at the top of the food chain. Many chemical substances present in wastewaters like heavy metals (mercury, cadmium, lead etc.) fluoride and nitrate can affect human health. The adverse effects of some of these have already been discussed in Unit 5. Metals can contaminate food while cooking in various types of utensils including alloys like steel. Containers for canned food, especially which are acidic in nature, contaminate the food with lead. Lead also comes in water from the water-pipes where it is added for plumbing purposes. Various alcoholic beverages contain lead while tobacco contains cadmium that goes in the body and affects human health.

Various chemicals, gases and particulates laden with chemicals, spewed into the environment from various industries cause air pollution and affect human health. The details of effects of air pollution on human health have already been given in Unit 5.

**Noise:** Although human ear is capable of tolerating a range of sound levels, yet if sound levels beyond the permissible level exist for certain duration, it becomes painful and sometimes irreparable damage occurs. Besides hearing damage various types of physiological and psychological changes are induced by noise pollution. The details of effects of noise on human health are given in Unit 5.

**Radiations:** Radiations are known to cause short-term and long-term changes in various organs. Cosmic rays and ultra-violet rays cause

harmful effects on human health which may include cancer. The details of ill effects of radiations on human health are given in Unit 5.

**Diet:** Diet has a very important role in maintaining health. Malnutrition makes humans prone to other diseases. There is a strong correlation between cardiovascular diseases and the amount of salt and fat in one's diet. Food contamination can cause various ill effects. There had been cases of Dropsy in India, a disease which occurred due to contamination of mustard oil with the poisonous seeds of *Argemone mexicana*. Likewise various adulterated pulses, condiments, oils etc. sold in the market to earn profit affect human health.

**Settlement:** Proper environment, availability of basic necessities of life like, water, sanitation etc. are essential for healthy living. Housing is very important from security point of view. Improper settlement and poor physical environment may cause various psychological problems which affect various vital physiological processes in the body.

## ■ HUMAN RIGHTS

Human rights are the rights that a human being must enjoy on this earth since he/she is a human being. Although the foundation of human rights was laid in the 13th century when resistance to religious intolerance, socio-economic restraints and scientific dogmas resulted in some revolts mainly due to the liberal thoughts of some philosophers. However, true hopes for all people for happy, dignified and secure living conditions were raised with the **Universal Declaration of Human Rights (UNDHR)** by the UNO on **December 10, 1948**. This declaration provided comprehensive protection to all individuals against all forms of injustice and human rights violations. The UNDHR defines specific rights, civil, political, economic, social as well as cultural. It defines the rights to life, liberty, security, fair trial by law, freedom of thought, expression, conscience, association and freedom of movement. It emphasizes right to equal pay for equal work, right to form and join trade unions, right to health care, education, adequate rest etc.

Although the human rights are considered to be universal, there is a wide disparity between the developing and the developed countries. Population and poverty are often found to be the most important causes of violation of human rights in the third world countries. Poverty often undermines human dignity and without dignity there is no meaning of human right. In fact, talks of human rights seem justified only when one can just manage to live on. The ***World Health Organisation estimates indicate that one out of every five persons in this world is malnourished, lacks clean drinking water, lacks proper hygienic conditions***

***and adequate health facilities; one out of three persons does not have enough fuel to cook or keep warm and one out of five persons is desperately poor for whom life is nothing but struggle for survival. Every year 40 million people are dying due to consumption of contaminated drinking water.*** There is acute scarcity of employment in the third world countries. Under such conditions, a poor man feels that perhaps his child can earn something for himself or the family. For him, the merit of universal education and child labour prevention is of much less importance than his grim struggle for existence.

For the developed countries, which have already attained a high stage of development in material and economic resources, the social and economic rights are not that important as civil and political rights. Whereas, the reverse is true for the developing countries which are struggling for life under conditions of extreme poverty, ignorance, illiteracy, malnutrition and diseases. For them the civil and political rights carry little meaning. In June 1993, during the **Vienna World Conference on Human Rights** the need for economic and social rights were considered as equal to the west's political and civil rights. Respect towards human rights is now considered to be one of the important criteria for giving development assistance to a country. In 1992, the Burton Bill passed in USA slashed 24 million dollars of development assistance to some developing countries including India on the grounds of showing poor human rights records.

In India, human right issues have mostly centered around slavery, bonded labour, women subordination, custodial deaths, violence against women and minorities, child abuse, dowry deaths, mass killings of dalits, torture, arbitrary detentions etc. The constitution of India contains a long list of people's civil, political, economic and social rights for improving their life. Yet, it is an irony that violation of human rights takes place rather too often in our country. Social discriminations, untouchability, patriarchal society with male domination etc. still prevail in the society which hinder the honour of human rights. Civil liberties and fundamental freedom are also often violated by those who have money power. Communal violence against minorities has become quite prevalent in our country. There is a need to respect the human rights of all people in every nation for overall development and peace.

As the right to development was defined, another aspect of human right related to environment emerged. After the Earth Summit 1992, the need for sustainable development was recognized. Soon after on May 16, 1994 at Geneva, the United Nations drafted the first ever **Declaration of Human Rights and Environment**, which embodies the

right of every human being to a healthy, secure and ecologically sound environment. A sustainable society affirms, equity, security, attainment of basic human needs and environmental justice to all.

It is quite disheartening to look at the environmental inequities. The developed nations utilizing most of the natural resources and reaping the benefits of industrial development are not bearing the burden of their hazardous wastes, as they export such wastes to many developing countries who have to face the toxic impacts of the hazardous wastes. The worker class and the poor are the main victims and sufferers of adverse effects of industrial toxins, foul smelling polluted air, unclean and unsafe drinking water, unhealthy working conditions, occupational health hazards etc. The indigenous people and tribal people are the worst victims of development who lose their homes and lands to dams and reservoirs and are deprived of their human rights to native homes.

### Draft Declaration of Human Rights and Environment

The draft declaration describes the rights as well as duties that apply to individuals, governments, international organizations and trans-national corporations.

The preamble envisages a deep concern regarding the consequences of environmental harm caused by poverty, debt programmes and international trade. Environmental damages are often irreversible. Human rights violations may lead to further environmental degradation on a long-term basis and the environmental degradation, in turn would lead to further human rights violation.

The principles of the draft declaration are divided into five parts.

**Part I:** It deals with human rights for an ecologically sound environment, sustainable development and peace for all. It also emphasizes the present generation's rights to fulfill its needs to lead a dignified and good quality life. But, at the same time it lays stress on the fact that it should be without impairing the rights of the future generations to meet their needs.

**Part II:** It mainly deals with human rights related to an environment free from pollution and degradation. It also emphasizes the rights to enjoyment of natural ecosystems with their rich biodiversity. It defines right to own native land or home. No one can be evicted from one's native place except in emergency or due to a compelling purpose benefitting the society as a whole which is not attainable by other means. All persons have the right to timely assistance in the event of any natural or technological disaster.

**Part III:** It deals with right of every person to environmental information, education, awareness and also public participation in environmental decision making.

**Part IV:** It deals with the duties to protect and preserve the environment and prevent environmental harm. It includes all remedies for environmental degradation and measures to be taken for sustainable resource use. It emphasizes that states shall avoid using environment as a means of war and shall respect international law for protection of environment.

**Part V:** This lays stress on social justice and equity with respect to use of natural resources and sustainable development.

Till now, however, it has not been defined in practical terms the threshold, below which level of environmental quality must fall before a breach of individual human right will said to have occurred or above which the level of environmental quality must rise. 'Right to development' has to be linked to 'right to safe and clean environment' which has to be considered not only at the level of individual but at community, national and global level.

## ■ VALUE EDUCATION

Education is one of the most important tools in bringing about socio-economic and cultural progress of a country. However, the objective of education should not merely be imparting coaching to the students that they get through the examinations with good results and get some good job. Education does not simply mean acquiring a lot of information but also its righteousness and use within the framework of a spectrum of ethical values.

The rapid strides of scientific and technological advancements have no doubt, brought revolutionary changes in our every day life and information technology has shrunk the whole world into a "global village", with access to very information sitting in one corner over the internet. But, in this frenzy for development and mad race for progress perhaps man has become too materialistic, self-centered and over ambitious and the desired ideals of a real good life have been pushed to the background. Value-based education thus has a very significant role in providing proper direction to our youth, to inculcate a positive attitude in them and to teach them the distinction between right and wrong. It teaches them to be compassionate, helpful, peace loving, generous and tolerant so that they can move towards a more harmonious, peaceful, enjoyable and sustainable future.

Value education helps in arriving at value-based judgements in life based on practical understanding of various natural principles rather than acquiring certain prejudices. Value education encompasses human values, social values, professional values, religious values, national values, aesthetic values and environmental values. Value education increases awareness about our national history, our cultural heritage, national pride, constitutional rights and duties, national integration, community development and environment.

Value education has different phases *i.e.* value awareness, value orientation, value appraisal, value selection, value commitment and value action. The basic aim is to create and develop awareness about the values, their significance and role. After knowing them the student's mindset would get oriented towards those values and he will try to critically analyse the same and then select the values which really appeal to him. This will be followed by commitment that needs to be re-affirmed over and over again so that every action is taken keeping those values in view.

### Value-based Environmental Education

Environmental education or environmental literacy is something that every person should be well versed with. The principles of ecology and fundamentals of environment can really help create a sense of earth-citizenship and a sense of duty to care for the earth and its resources and to manage them in a sustainable way so that our children and grand children too inherit a safe and clean planet to live on.

We have already discussed about environmental ethics, earth-citizenship and ways and means to propagate environmental education and awareness. **Following the Supreme Court directives (in M.C. Mehta Vs. Union of India, 1988) environmental education has been included in the curriculum right from the school stage to college/university level. The prime objective of the same is to make everyone environment literate.** The environment belongs to each one of us and our actions affect the environment. When the environment gets degraded it affects our health, well-being and our future. So we have a right to know the a b c of environment and also have a right to safe and clean environment.

Let us now see how environmental education be made value-based.

1. Preparation of text-books and resource materials about environmental education can play an important role in building positive

attitudes about environment. The basic **human value** 'man in nature' rather than 'nature for man' needs to be infused through the same.

2. **Social values** like love, compassion, tolerance and justice which are the basic teachings of most of our religions need to be woven into environmental education. These are the values to be nurtured so that all forms of life and the biodiversity on this earth are protected.

3. **Cultural and religious values** enshrined in Vedas like "*Dehi me dadami te"* i.e. "you give me and I give you" (Yajurveda) emphasize that man should not exploit nature without nurturing her. Our cultural customs and rituals in many ways teach us to perform such functions as would protect and nurture nature and respect every aspect of nature, treating them as sacred, be it rivers, earth, mountains or forests.

4. Environmental education should encompass the **ethical values** of earth-centric rather than human-centric world-view. The educational system should promote the earth-citizenship thinking. Instead of considering human being as supreme we have to think of the welfare of the earth.

5. **Global values** stress upon the concept that the human civilization is a part of the planet as a whole and similarly nature and various natural phenomena over the earth are interconnected and inter-linked with special bonds of harmony. If we disturb this harmony anywhere there will be an ecological imbalance leading to catastrophic results.

6. **Spiritual values** highlight the principles of self-restraint, self-discipline, contentment, reduction of wants, freedom from greed and austerity. All these values promote conservationism and transform our consumeristic approach.

The above-mentioned human values, socio-cultural, ethical, spiritual and global values incorporated into environmental education can go a long way in attaining the goals of sustainable development and environmental conservation. Value-based environmental education can bring in a total transformation of our mind-set, our attitudes and our life-styles. "What is the use of building a beautiful house if you don't have a decent planet to place it on?"- perhaps this single question can answer the main burning question- "What is real development and progress?" We certainly do not want development in exchange of environmental disasters, health hazards, loss of mental peace and merciless destruction of nature's beauty and natural resources. The value elements in environmental education alone can succeed in achieving the real goals of environmental literacy.

## ■ HIV/AIDS

AIDS, the Acquired Immuno Deficiency Syndrome is not a hereditary disease but is caused by HIV (Human Immunodeficiency Virus). HIV from an infected person can pass to a normal person through blood contact generally during unprotected sex with infected person and sharing needles or syringes contaminated with small quantities of blood from HIV positive person. HIV can also pass from infected mothers to their babies during pregnancy, delivery or breast feeding. HIV, however, doesn't spread through tears, sweat, urine, faeces or saliva during normal kissing. It also does not spread by sharing utensils, towels, clothing, toilet seats or insect bite like that of mosquito or bed bug.

According to a recent estimate about 40 million people are living with HIV/AIDS worldwide and 70% of them in Sub Saharan Africa. HIV/AIDS has been identified as the fourth largest cause of mortality. About 3 million people died due to HIV/AIDS in 2003. AIDS is rapidly spreading in eastern Europe and Asia. It is expected that in the coming decades there will be sharp increase in HIV/AIDS cases in Russia, China, and India.

AIDS was discovered in 1983. Although sufficient knowledge has been gained about the disease yet a definite source of this virus could not be identified.

Most evidences have suggested that AIDS has spread from Africa. It is believed that the virus has been transferred to humans from primates like African Monkey (White sooty mangabeys) or chimpanzees.

According to another theory HIV has spread through vaccine programmes in various parts of the world in the following manner:

1. HIV has spread in Africa through HIV contaminated polio vaccine prepared by using monkey's kidney.

2. It had spread through hepatitis B viral vaccine in New York, Los Angeles and San Francisco.

3. It has spread through small pox vaccine programme of Africa.

It is also hypothesized that AIDS is a man made epidemic produced by genetically engineered laboratory produced virus. AIDS itself does not kill humans. The deaths occur due to attack by other diseases because of the weakening of immune system. There is decline in T-cells which are the key infection fighters in the immune system. HIV destroys or disables these cells as a result of which various types of infectious diseases due to microbial invasion occur. Even dreaded disease like cancer can easily develop in the HIV infected persons.

Consumption of alcohol is understood to increase the susceptibility to infection and progression of AIDS.

### Effects of HIV/AIDS on Environment

When there is an AIDS epidemic large number of deaths occur which adversely affect local environment and natural resources. Due to large number of deaths there is loss of labour and the level of production decreases. With fewer adults, young members with limited resources like land and lack of experience and knowledge find it difficult to look after the perennial crops and prefer crops requiring less labour and time. They devote less time for soil conservation, forestry conservation, especially if there are deaths of professional forest workers. Demand of easily accessible fuel wood increases. More timber is required for making coffins or for pyre making. More water is required for maintaining hygiene in AIDS affected locality. The HIV carriers are also not able to perform well due to lack of energy and frequent fever and sweating.

## ■ WOMEN AND CHILD WELFARE

Women and children are usually the soft targets, who suffer in a number of ways mainly because they are weaker, helpless and economically dependent.

### Women Welfare

Women usually suffer gender discrimination and devaluation at home, at workplace, in matrimony, in inheritance, in public life and power, particularly in developing countries. The gender violence, victimization and harassment take many forms across culture, race or nation. The statistical data provided by the Ministry of Women and Child Development is an eye opener that deglorifies the celebrated culture of our country. The exceptionally high number of cases of abduction, dowry deaths, rape, domestic violence, criminal offences and mental torture to women is something that needs immediate attention and reforms in the interest of the women. Women are often the worst victims of communal enimities. The human rights of women are violated too often in a male dominated patriarchal society. Thus, there is an urgent need for policy reforms and more stringent legislation as well as educational and legal awareness amongst women for checking the atrocities and injustice towards her. There are now many **'Women Groups'** who actively take up women welfare issues and legally constituted **"Women cells"** that exist almost everywhere and fight for

protection of women rights and dignity. There is a full-fledged **Ministry for Women and Child development** whose sole aim is to work for the welfare and upliftment of women encompassing family planning, health care, education and awareness. There is a need for complete transformation and reorientation of social ethos for restoring the dignity, status, equality and respect for women.

Women are also the victims of capitalism, development and environment. The exploitative nature of capitalist development not only affects the natural environment but the traditional, social, cultural and family life of women. After losing the forests and getting dehabilitated from their native places, men folk usually migrate to towns in search of some job while the women are left behind to look after the family and household with little resources. Development projects like mining very often play havoc with the life of women. Men can still work in the mines or migrate to towns after getting compensation from the government. The **National Network for Women and Mining (NNWM)** with about 20 groups in different mining states of India is rightly fighting for a **"gender audit"** of India's mining companies. The displaced women are the worst affected as they do not get any compensation and are totally dependent upon the males for wages. The displaced women driven out from their land-based work are forced to take up marginalized work which is highly un-organised and often socially humiliating. Issues related to their dignity and honour have not yet received any attention. The NNWM is now working for rights of women over natural resources, resettlement and compensation issues.

Besides the government initiatives there are now a number of non-government organizations (NGO's), mostly as **"Mahila Mandals"** to create awareness amongst women of remote villages even to empower them, train them, educate them and help them to become economically self-dependent.

On an international level, the **United Nations Decade for Women (1975-85)** witnessed inclusion of several women welfare related issues on international agenda. The **CEDAW (International Convention on the Elimination of all forms of Discrimination Against Women, 1979)** has been a landmark outcome of the decade to be accepted as an international standard for the protection and promotion of women's human rights and socio-economic upliftment. It is, however, most important for all women, in the mainstream, tribals, refugees and the down-trodden to be educated about these issues.

### Child Welfare

Children are considered to be the assets of a society. But, ironically, the statistical figures tell us that about a million babies, out of 21 million born every year in India are abandoned soon after their birth due to different socio-economic reasons. Around 20 million children in our country are estimated to be working as child labours, some of them in various hazardous industries like the match industry, firework industry, brassware industry and pottery industry. Poverty is the main reason to drive these children into long hours of work in miserable, unhealthy conditions and yet they do not get the minimum nutritive food, what to talk of educational and recreational facilities, which are their childhood rights.

The UN General Assembly in **1959** adopted the **Declaration of the Rights of a child**. After the UN convention on Rights of Child, it became **International Law** in the year 1990, consisting of 54 articles and a set of international standards and measures to promote and protect the well being of children in a society.

The law defines right of the child to survival, protection, development and participation. The right to survival emphasizes on adequately good standards of living, good nutrition and health. The right to protection means freedom from exploitation, abuse, inhuman treatment and neglect. The right to development ensures access to education, early childhood care and support, social security and right to leisure and recreation. The right to participation means freedom of thought, conscience and religion and appropriate information to the child.

The **World Summit on Children**, held on September 30, 1990 had a focussed agenda for the well being of the children targeted to be achieved in the beginning of the new millennium. India is also a signatory to the **World Declaration on Survival, protection and development of children**. A national plan of action for children has been formulated by the **Ministry of Human Resource Development (MHRD)**, Government of India in which a strategic plan has been formulated for children's welfare in the priority areas of health, education, nutrition, clean and safe drinking water, sanitation and environment. Universalisation of effective access to at least primary level schooling, special emphasis on girl child's education including health and nutrition, upgradation of home-based skills, mid-day meals scheme, expansion of early childhood development activities including low-cost family based involvements are some of the important actions envisaged.

Children are also the most affected due to environmental pollution. ***"They consume more water, food and air than adults, hence more susceptible to any environmental contamination"***- says one of the scientific reports of Center for Science and Environment (CSE), New Delhi. Water borne diseases are the biggest threat to children, affecting around 6 million children in India. Childhood cancer rates are also increasing by 6% every year. Even the growing foetus in the mother's womb is not safe and free from the adverse effects of environmental toxins. It is high time to work together for a secure and cleaner environment so as to give our children a cleaner and safer world to live in.

## ■ ROLE OF INFORMATION TECHNOLOGY IN ENVIRONMENT AND HUMAN HEALTH

Information technology has tremendous potential in the field of environmental education and health as in any other field like business, economics, politics or culture. Development of internet facilities, worldwide web, geographical information system (GIS) and information through satellites has generated a wealth of up-to-date information on various aspects of environment and health. A number of soft-wares have been developed for environment and health studies which are user friendly and can help an early learner in knowing and understanding the subject.

### Database

Database is the collection of inter-related data on various subjects. It is usually in computerized form and can be retrieved whenever required. In the computer the information of database is arranged in a systematic manner that is easily manageable and can be very quickly retrieved. The Ministry of Environment and Forests, Government of India has taken up the task of compiling a database on various biotic communities. The comprehensive database includes wildlife database, conservation database, forest cover database etc. Database is also available for diseases like HIV/AIDS, Malaria, Fluorosis, etc.

**National Management Information System (NMIS)** of the Department of Science and Technology has compiled a database on Research and Development Projects along with information about research scientists and personnel involved.

**Environmental Information System (ENVIS):** The Ministry of Environment and Forests, Government of India has created an Information System called Environmental Information System (ENVIS). With its headquarters in Delhi, it functions in 25 different

centers all over the country. The ENVIS centers work for generating a network of database in areas like pollution control, clean technologies, remote sensing, coastal ecology, biodiversity, western ghats and eastern ghats, environmental management, media related to environment, renewable energy, desertification, mangroves, wildlife, Himalayan ecology, mining, etc. The National Institute of Occupational Health provides computerized information on occupational health i.e. the health aspects of people working in various hazardous and non-hazardous industries, safety measures etc.

### Remote Sensing and Geographical Information System (GIS)

Satellite imageries provide us actual information about various physical and biological resources and also to some extent about their state of degradation in a digital form through remote sensing. We are able to gather digital information on environmental aspects like water logging, desertification, deforestation, urban sprawl, river and canal network, mineral and energy reserves and so on. Geographical Information System (GIS) has proved to be a very effective tool in environmental management. **GIS is a technique of superimposing various thematic maps using digital data on a large number of inter-related or inter-dependent aspects.** Several useful soft-wares have been developed for working in the field of GIS. Different thematic maps containing digital information on a number of aspects like water resources, industrial growth, human settlements, road network, soil type, forest land, crop land or grassland etc. are superimposed in a layered form in computer using softwares. Such information is very useful for future land-use planning. Even interpretations of polluted zones, degraded lands or diseased cropland etc. can be made based on GIS. Planning for locating suitable areas for industrial growth is now being done using GIS by preparing **Zoning Atlas.** GIS serves to check unplanned growth and related environmental problems. Our satellite data also helps in providing correct, reliable and verifiable information about forest cover, success of conservation efforts etc. They also provide information of atmospheric phenomena like approach of monsoon, ozone layer depletion, inversion phenomena, smog etc. We are able to discover many new reserves of oil, minerals etc. with the help of information generated by remote sensing satellites. Thus remote sensing and GIS play a key role in resource mapping, environmental conservation, management, planning and environmental impact assessment.

It also helps in identifying several disease infested areas which are prone to some vector-borne diseases like malaria, schistosomiasis etc. based upon mapping of such areas.

There are several **Distribution Information Centres (DICs)** in our country that are linked with each other and with the central information network having access to international database.

**World Wide Web:** A vast quantum of current data is available on World Wide Web. One of the most important on-line learning center with power web is www.mhhe.com/environmental science and multimedia Digital Content Manager (DCM) in the form of CD-ROM provides the most current and relevant information on principles of environmental science, various problems, queries, applications and solutions.

The World Wide Web with resource material on every aspect, class-room activities, digital files of photos, power-point lecture presentations, animations, web-exercises and quiz has proved to be extremely useful both for the students and the teachers of environmental studies.

The role of online learning center website has the following features:

(*a*) **Student friendly features:** These include practice quiz, how-to study tips, hyperlinks on every chapter topics with detailed information, web exercises, case studies, environment maps, key-terms, career information, current articles, interactive encyclopedia and how to contact your elected officials.

(*b*) **Teacher-friendly features** include in addition to above supplement resource charts, additional case studies, answers to web exercises, solutions to critical thinking questions, editing facility to add or delete questions and create multiple versions of same test etc.

Information technology is expanding rapidly with increasing applications and new avenues are being opened with effective role in education, management and planning in the field of environment and health.

## QUESTIONS

1. What do you mean by (*a*) Doubling time (*b*) Total fertility rate (*c*) Zero population growth (*d*) Life expectancy.
2. How can age-structure pyramids serve as useful tools for predicting population growth trends of a nation ? Explain with examples.
3. What is meant by 'Population Explosion' ? Discuss the Indian scenario.
4. What is meant by population stabilization ? Discuss the family welfare and family planning program in Indian context.

**5.** Discuss the influence of environmental parameters and pollution on human health.

**6.** What is Universal Declaration of Human Rights ? What is its importance in achieving the goals of equity, justice and sustainability ?

**7.** Discuss the salient features of Draft declaration of Human Rights and Environment.

**8.** What are the objectives and elements of value education ? How can the same be achieved ?

**9.** Briefly discuss HIV/AIDS, mode of its spread and its effects on environment.

**10.** Discuss various issues and measures for women and child welfare at international and national level.

**11.** What is the role of NMIS, ENVIS and GIS in dissemination of environmental information and environmental management.

Unit

# 8 Field Work

## ■ VISIT TO A LOCAL AREA TO DOCUMENT ENVIRONMENTAL ASSETS

Visit may be planned to any nearby river, forest, grassland, hill or mountain, depending upon easy access and importance. Write a report based on your observations and understanding about various aspects of environment. The contents of this book (Unit 1-7) provide the required information for the study and for arriving at some important conclusions about the system.

### (A) STUDY OF RIVER ENVIRONMENT

**1. Background data:** Note down the name of the river or tributary, its place of origin and its course or route. Find out whether the river is perennial or seasonal in nature.

**2. Water quality observations:**

(*i*) Note down whether the water of the river is clear or turbid.

- If it is clear, what do you expect? Penetration of light into the water would be more, therefore green aquatic plants will be growing better. The primary productivity will be high.
- If it is turbid, how would it affect the primary productivity of the river? You know that sunlight penetration is obstructed by turbidity.

(*ii*) Note the temperature of water with a thermometer or thermoprobe. Also note the temperature of the air.

- If the temperature of the river water is quite high (> 5°C than the ambient water temperature), what can be the reason? Find out if any thermal pollution is occurring in the river due to discharge of effluents from some industry.
- Write down the probable impacts of thermal pollution on aquatic life.

(*iii*) Do you observe any froth and foam or dark coloured or greasy substances in the river?

If yes, then what are these? Find out the likely sources of these pollutants.

(*iv*) Is there any point along the river stretch under study from where discharge of wastewater (industrial/municipal sewage) is being done into the river? If yes, then look for the visual differences in water quality at the upstream and downstream sites.

(*v*) Determine the pH of water using a portable pH-scan. The pH would normally range between 6.5 to 8.5. If the pH is quite low i.e. acidic waters, it indicates pollution by industries. If the pH is quite high i.e. alkaline, it indicates contamination by municipal sewage.

Is your river water of good quality or it is polluted?

**3. Observations on aquatic life**

(*i*) Look for different types of life forms. Do you find some free-floating small plants (phytoplanktons) or small animals (zooplanktons)? Are there some rooted plants seen underneath? Do you observe aquatic animals like different fishes, tortoise/turtle, crocodile/alligater, water snake etc.? What are the important aquatic birds seen by you?

(*ii*) Draw a food-web diagram that would be present in the river.

**4. Uses:** How is the river water used? Prepare a list of the uses.

**5. Human impacts:** What are the major impacts caused by human beings in your area on the river? Have you learnt of any major incident e.g. massive fish death or cattle death or skin problems to human beings consuming the water? Try to interpret the same.

## (B) STUDY OF A FOREST

(*i*) **Background data:** Note down the name of the forest. What type of a forest is it i.e. a tropical rain forest/deciduous forest etc. ? Is the present forest, a part of some Biosphere reserve or National park or Sanctuary?

If yes, then what are the special features associated with it?

(*ii*) **Forest structure:** Note down the salient features of the forest.

- What are the dominant trees? Are there any herbaceous climbers or woody climbers? Is the forest having a close canopy or has open spaces?
- Does the forest show a thick/dense growth or it is degraded?
- Is there an understory of shrubs, herbs and grasses of lower height?

- Is there a thick or thin forest floor consisting of leaf litter (dry dead leaves), algae, fungi etc.? What is the use of stratified structure i.e. multi-layered structure of vegetation in the forest?

(*iii*) **Commercial uses:** Prepare a list of the various uses of the present forest.

(*iv*) **Ecological utility:** Do you feel cooler in the forest? Is it more humid? Is the air more fresh than that in the city? How many types of birds, animals or insects do you see around? Make a list of the ecological uses of the forest based on your observations.

(*v*) **Human impacts:** Do you observe any anthropogenic activities in the forest *e.g.* mining, quarrying, deforestation, dam building, grazing, timber extraction etc.?

What would be their probable impacts?

## (C) ENVIRONMENTAL ASPECTS OF A GRASSLAND

(*i*) **Background information:** What type of grassland is this? Is it perennial or annual? Are there tall grasses or short grasses? Is it dominated by just a few species or is it a mixed type of grassland? Is it protected *i.e.* fenced or disturbed?

(*ii*) **Grassland quality observations:**

- Try to identify the names of some of the dominant grasses or plants. Are these dominant plants having a soft, delicate, juicy nature with green colour showing good palatability? OR the dominant plants have a coarse, hard texture with spines/ thorns?
- Take out a few plants to see what type of roots do they have, Are there numerous fibrous roots in a bunch, (adventitious roots), runner-type, having rhizomes or there is a single, long tap root?
- If the roots are adventitious, they tend to bind the soil particles firmly and help in conserving the soil. If the root is tap root, then it cannot help in binding the soil particles firmly. What is the condition dominant in the present grassland? Do you observe soil erosion?

(*iii*) **Grazing and Overgrazing:** Find out if there is managed grazing on the grassland i.e. only a limited number of livestock (cattle) is being allowed to graze OR there is unmanaged grazing.

Normal grazing is useful for increasing the overall productivity/ yield of the grassland. Overgrazing has several far reaching

consequences. Make your own observations in the present grassland i.e. whether there is limited grazing or overgrazing?

- If you find that good quality grasses/herbs are growing then it is rightly grazed.
- If you see denuded areas with little grass cover it shows overgrazing.
- If you observe thorny, hard, prickly plants occupying some areas, it indicates degradation of the grassland due to overgrazing.

(*iv*) **Uses:** Prepare a list of the utilities of the grassland.

## (D) STUDY OF MOUNTAIN/HILLY AREA

(*i*) **Background data:** Note down the name of the mountain ranges or the hills. Note down the altitude of the region. Find out the average annual rainfall and temperature in the area.

(*ii*) **Observations on natural vegetation:** Make your observations on the forests present on the hill slopes. Do you find dense forests on the hills or deforestation is observed in some areas? Look for some dominant tree species and find out their names and uses from local people.

(*iii*) **Landslides:** You will come across some regions, where landslide would have occurred recently or in the past. Do you observe any major anthropogenic activity there? What is the condition of forest growth in the region? Can you establish some links between these aspects? You can gather some information about such aspects from the native people.

(*iv*) **Water-sheds:** Try to look for some springs, rivers and channels coming out from the mountains. The land area from which water drains under gravity to a common drainage channel is called watershed.

Gather some information about the water shed in the study area, its uses and its status i.e. whether it is well managed or degraded.

(*v*) **Plantations/Farming:** Look for the type of plantations (*e.g.* tea plantation) or farming (e.g. maize, wheat) done artificially on the hill slops.

- What type of farming is done? Is it shifting cultivation, traditional or modernized? What would be their impacts?
- Do you observe terrace farming, contour or strip cropping? Why is such cropping helpful in hills?

- Find out the water and nutrient requirements of these crops. Do you find these crops/plantations well suited to hill environment OR do you think they can have some damaging effects later on? Discuss with local people.

(*iv*) How much anthropogenic activities do you observe on the mountain/hill?

These activities usually include mining, quarrying, tourism, construction, hydroelectric projects etc. What major impacts do you observe or predict in future?

## ■ VISIT TO SOME LOCAL POLLUTED SITE

Human activities related to urbanization and industrialization have led to large scale pollution of the environment. Agricultural practices have also led to pesticide pollution, water logging and salinization. A visit to some industrial area or degraded land area will be very useful to obtain first hand information about the same.

### (A) STUDY OF AN INDUSTRIALLY POLLUTED AREA

(*i*) **Background data:** Note down the name of the industry, its capacity, year of establishment, the type of product and the type of wastes/emissions produced by it.

(*ii*) **Pollution aspects:** Look at the stacks (chimneys) in the area which might be giving certain emissions. What are the toxic gases present in them - are they obnoxious smelling? As the wind blows, do they move in a direction that is towards the city or in other direction?

Do you observe huge heaps of sludge around/outside the factory? Do you find any trees or other plants growing in such dumping sites?

Find out if there is any Effluent Treatment Plant (ETP) within the industry to treat the wastes before discharging them. You can also see the working of an ETP, with prior permission from the industry people.

(*iii*) **Green belt:** Do you observe a green belt planted around the industry? It has now become mandatory for all big industries to plant green trees around the industry.

This is because the tree canopy (leaves) has got an excellent capacity to absorb various pollutants and also reduce noise. They also release oxygen to make the atmosphere pure.

(*iv*) **Health aspects:** Try to get information about any serious health impacts in the people living in the vicinity of the industry. e.g.

- The water drawn from tubewells/hand pumps may be contaminated with some toxic substances/dyes etc. which on drinking may cause health ailments.
- The toxic gases and suspended particulate matter released by the industry is inhaled by the people living nearby which might cause skin irritation/allergy/respiratory problems.

## (B) STUDY OF A WATER-LOGGED/SALINE LAND

(*i*) **Background information:** Visit a water logged or salt-affected land in some rural agricultural area. An area having permanently standing water on the soil is a water-logged soil. You can observe crusts of white salts on the soil surface making it barren-that is a saline soil.

Gather information from the farmers about its historical background i.e. how much irrigation was being done in these areas and for how long? Was the area fertile some years ago and has gradually become water-logged and saline? What was the crop grown earlier? Try to correlate the problem with the irrigation practices followed there.

(*ii*) **Salinity and crop growth:**

- Find out the salinity level (Electrical conductivity, EC) of the soil. For this you can take 10 grams of soil and dissolve it in 20 ml of water in a beaker. Dip an EC probe into it which will indicate the EC of the soil. The non-saline normal soil has EC < 4 dS/m. If the EC exceeds 4, it is saline. The EC can be as high as 20-40 dS/m also. But then it would hardly support any vegetation.
- Do such soils support any crops? Note down the names of the salt-tolerant and salt-sensitive crops.

(*iii*) **Remediation:** Find out what remedial measures are being taken by the farmer to deal with the problem. What measures can you suggest.

## ■ STUDY OF COMMON PLANTS, INSECTS AND BIRDS

Biodiversity or the variability among plants, animals and microbes found on this earth is just remarkable and has tremendous potential in terms of its consumptive, productive, social, ethical and ecological value. It is worthwhile to know about some common plants, insects and birds of our locality.

(*a*) **Plants:** Study the common plants of your locality, including trees, shrubs and herbs. You can study them mainly in relation to their value.

(*i*) **Medicinal plants:** Local people often have indigenous knowledge about the medicinal value of various plants. Find out which of the plants in your locality have medicinal value ?

(*ii*) **Timber wood trees:** Note down the important trees of your locality which yield timber wood.

(*iii*) **Miscellaneous:** Note down the names of plants which have other uses like producing gum, resins, tannin, dye, rubber, fibre etc.

(*b*) **Insects:** Identify some common insects of your locality

(*i*) which may be spreading diseases.

(*ii*) Which are crop-pests or animal pests.

(*iii*) Which help in pollination of ornamental/crop flowers.

(*c*) **Birds:** Identify some common birds of your locality. Find out how some of them are useful to us and some cause damage to our crops/fruits. Observe small birds with long beaks pollinating flowers. Observe the birds in the ploughed fields eating insects/larvae.

# Objective Type Questions

## UNIT 1 : ENVIRONMENTAL STUDIES—A MULTI-DISCIPLINARY SUBJECT

### A. FILL IN THE BLANKS

1. The term 'Environment' has been derived from the French word ..... which means to encircle or surround.
2. The United Nations Conference on Environment and Development (Earth Summit) was held at ..... in ..... .
3. The World Summit on Sustainable Development was held at ..... in ..... .
4. Hon'ble ..... Court of India issued directive to make all curricula environment-oriented.
5. Mr. ..... filed PIL (Public Interest Litigation) for creating environmental awareness among all citizens of India.

## UNIT 2 : NATURAL RESOURCES

### A. FILL IN THE BLANKS

1. ..... resources are inexhaustible resources which can be generated within a given span of time.
2. ..... resources can not be generated.
3. Plants use ..... gas for photosynthesis.
4. Deforestation means ..... of forests.
5. ..... % of geographical area of a country should be forest area.
6. Maximum number of dams in India are in the ..... state.
7. ..... dam is the highest dam on river Bhagirathi in Uttaranchal.
8. The ..... dam on river Satluj in H.P. is the largest dam in terms of capacity.
9. Ecological issue related with Tehri Dam are taken up by Sh. ....., the leader of Chipko movement.
10. Environmental activist Medha Patekar has taken up issues related to ..... Dam.

11. About ..... % of the earth's surface is covered by water.
12. Only ..... % of totalwater on earth is readily available to us in the form of groundwater and fresh water.
13. A layer of sediment or rock that is highly permeable and contains water (ground water) is called an ..... .
14. Aquifers which are overlaid by permeable earth material and are recharged by seeping water are called ..... aquifers.
15. Aquifers which are sandwitched between two impermeable layers of rocks or sediments are called ..... aquifers.
16. ..... conditions are created when annual rainfall is below normal and less than evaporation.
17. The Cauvery river water is a bone of contention between ..... and ..... states.
18. Uranium mining is done in ..... in A.P.
19. ..... can be extracted from bauxite ore.
20. Excessive use of fertilizers cause ..... imbalance in soil.
21. Eutrophication of lakes is caused the excessive presence of ..... and ..... .
22. In water logged soils the plant roots do not get adequate ..... for respiration.
23. Ocean tides are produced by gravitational forces of ..... and ..... .
24. In India ..... deltas are the tidal power sites.
25. For operating ocean thermal energy conversion a difference of ..... °C or more is required between surface and deeper water of ocean.
26. ..... crops are latex containing plants rich in hydrocarbons.
27. Biogas is produced by ..... degradation (in the absence of oxygen) of biological wastes.
28. Gasohol is a mixture of ..... and ..... .
29. 95% of natural gas is ..... .
30. Nuclear energy by nuclear fission is generated when certain isotopes are bombarded by ..... .
31. Terrace farming is practised as a soil conservation measure in ..... areas.
32. Inadequate drainage and poor quality irrigation water often lead to ..... and ..... of soils.

## B. TICK THE RIGHT ANSWER

1. During photosynthesis trees produce
   (*a*) Oxygen (*b*) Carbon dioxide
   (*c*) Nitrogen (*d*) Carbon monoxide.
2. Forests prevent soil erosion by binding soil particles in their
   (*a*) Stems (*b*) Leaves
   (*c*) Roots (*d*) Buds.
3. Wood pulp is used for making
   (*a*) Lumbar (*b*) Chipboard
   (*c*) Paper (*d*) Plywood.
4. Deforestation rate is alarming in
   (*a*) Temperate countries (*b*) Tropical countries
   (*c*) Polar region (*d*) None of them.
5. Major causes of deforestation are
   (*a*) Shifting cultivation (*b*) Fuel requirements
   (*c*) Raw material for industries
   (*d*) All of these.
6. Major consequences of deforestation are
   (*a*) Destruction of natural habitat of wild species
   (*b*) Disturbances in hydrological cycle
   (*c*) Soil erosion
   (*d*) All of these.
7. Per capita use of water is the highest in
   (*a*) USA (*b*) India
   (*c*) Kuwait (*d*) Indonesia.
8. Ground subsidence occurs due to
   (*a*) Withdrawal of more groundwater than its recharge
   (*b*) More recharge of groundwater than its withdrawal
   (*c*) Equal rates of recharge and withdrawal
   (*d*) None of the above.
9. Which of the following dreams to become the water super power in the middle east countries
   (*a*) Kuwait (*b*) Syria
   (*c*) Jordan (*d*) Turkey.
10. The Satluj-Yamuna Link (SYL) canal dispute is between
    (*a*) Punjab and Haryana (*b*) Karnataka and Tamil Nadu
    (*c*) Delhi and U.P. (*d*) All of the above.

11. Over grazing results in
    (*a*) Productive soils (*b*) soil erosion
    (*c*) Retention of useful species (*d*) All of these.
12. Blue baby syndrome (methaemoglobinemia) is caused by the contamination of water due to
    (*a*) Phosphates (*b*) Sulphur
    (*c*) Arsenic (*d*) Nitrates.
13. Accumulation of non-biodegradable materials in the food chain is called
    (*a*) Biomagnification (*b*) Detoxification
    (*c*) None of these (*d*) Both of these.
14. Natural geysers which operate due to geothermal energy are present in
    (*a*) Manikaran in Kullu (*b*) Sohana in Haryana
    (*c*) None of them (*d*) Both of these.
15. Biomass energy can be obtained from
    (*a*) Energy plantations (*b*) Petro crops
    (*c*) Agricultural and urban waste biomass
    (*d*) All of these.
16. Which of the following types of coal has maximum carbon and calorific value ?
    (*a*) Anthracite (hard coal) (*b*) Bituminous (soft coal)
    (*c*) Lignite (brown coal) (*d*) Wood coal.
17. Nuclear energy can be generated by
    (*a*) Nuclear fusion (*b*) Nuclear fission
    (*c*) Both of these (*d*) None of these.
18. The minimum time needed for the formation of one inch of top soil is
    (*a*) 10 years (*b*) 50 years
    (*c*) 100 years (*d*) 200 years.
19. Minimum disturbance is caused to SOCl during
    (*a*) Contour farming (*b*) No-till farming
    (*c*) Terrace farming (*d*) Alley cropping.
20. Which of the following is responsible for desertification ?
    (*a*) Deforestation (*b*) Overgrazing
    (*c*) Mining (*d*) All of these.

## C. WRITE WHETHER THE FOLLOWING STATEMENTS ARE TRUE OR FALSE

1. Surface water is more in quantity than the groundwater. (True/False)
2. Networking of rivers is being proposed at national level to deal with the problem of floods. (True/False)
3. Under Indus Water Treaty, Indus, Jhelum and Chenab were allocated to India and Satluj, Ravi and Beas to Pakistan. (True/False)
4. Small dams are environmentally more sustainable than big dams. (True/False)
5. Copper mines are located in Khetri (Rajasthan). (True/False)
6. Mining of Uranium exposes local people to radioactive hazards. (True/False)
7. Dichlorodiphenyl trichloroethane is the technical name of aldrin. (True/False)
8. The major source of salinization of soil is excessive irrigation. (True/False)
9. Solar cells are made up of thin wafers of semi-conductor materials like silicon and gallium. (True/False)
10. Solar heat can not be used to operate street lights, water pumps, television, calculators etc. (True/False)
11. Ideal location for installation of wind-mills are coastal regions, open grasslands, hilly regions. (True/False)
12. Hydropower also causes environmental pollution. (True/False)
13. Geothermal energy is produced as a result of fission of radioactive material naturally present in rocks. (True/False)
14. Burning of dung produces biomass energy but doesn't destroy essential nutrients like N and P. (True/False)
15. Sludge left over in the biogas plant cannot be used as a fertilizer. (True/False)
16. Ethyl mercaptan (a foul smelling gas) is added to odourless LPG for instantaneous detection of any leakage. (True/False)
17. Soil erosion helps to maintain soil fertility. (True/False)
18. Alley cropping is intercropping of crops with trees or shrubs. (True/False)

19. Gully erosion is a mild type of soil erosion found in regions of low rainfall. (True/False)
20. The soil below a depth of 20 cm is the fertile soil. (True/False)

## UNIT 3 : ECOSYSTEMS

### A. FILL IN THE BLANKS

1. The term ecosystem was coined by ..... .
2. The organisms who feed directly on producers are called ..... .
3. Chemosynthetic organisms can produce organic matter through oxidation of ..... in the absence of sunlight.
4. The sequence of eating and being eaten in an ecosystem is called a ..... .
5. Biomagnification of the pesticide ..... in the food chain resulted in the thinning of shells in birds eggs.
6. Pyramid of ..... is always upright.
7. Movement of nutrients in an ecosystem is cyclic while flow of energy is ..... .
8. Guano deposits on the coasts of Peru are rich in the nutrient ..... .
9. The inherent property of all living organisms to resist change is called..... .
10. The ultimate stable and culminating community during succession is called a ..... .
11. The biggest flower in the plant kingdom is ..... .
12. The thick layer of ice found frozen under the soil surface throughout the year is called ..... .

### B. CHOOSE THE CORRECT ANSWER

1. The organisms which feed on dead organisms, wastes of living organisms are called
   (*a*) Chemotrophs (*b*) Carnivores
   (*c*) Detritivores (*d*) Decomposers.
2. The progressive accumulation of some non-biodegradable chemicals through the food chain is known as
   (*a*) Ecological balance (*b*) Biological magnification
   (*c*) Trophic structure (*d*) Bio-degradation.

3. Gross primary productivity is the highest in
   (*a*) Open oceans (*b*) Grasslands
   (*c*) Wet tropical forests (*d*) Agroecosystem.
4. The type of succession occurring on a base rock is called
   (*a*) Halosere (*b*) Lithosere
   (*c*) Hydrosere. (*d*) None of these.
5. The tropical grasslands in Africa with tall grasses scattered with shrubs or stunted trees are called
   (*a*) Savannas (*b*) Pampas
   (*c*) Steppes (*d*) Prairies.
6. The darker zone in lakes where light penetration is negligible is called
   (*a*) Littoral zone (*b*) Limnetic zone
   (*c*) Profundal zone (*d*) Euphotic zone.
7. The overnourished lakes with 'algal blooms' are called
   (*a*) Eutrophic (*b*) Oligotrophic
   (*c*) Dystrophic (*d*) Meromictic.
8. Estuaries have the following characteristics
   (*a*) Fresh and salt-water
   (*b*) Rich biodiversity
   (*c*) High productivity
   (*d*) All of these.

## C. WRITE TRUE OR FALSE

1. An ecosystem is a group of biotic communities interacting with one another but without exchanging energy and matter with the non-living environment. (True/False)
2. Detritivores are also known as saprotrophs. (True/False)
3. Biotic and abiotic components of an ecosystem influence each other and are linked through energy flow and matter cycling. (True/False)
4. Food webs provide less stability to an ecosystem as compared to linear food chain. (True/False)
5. Double or Y-shaped energy flow model shows flow of energy through both grazing and detritus food chain. (True/False)
6. Microorganisms play a crucial role in cycling of nitrogen. (True/False)

7. The major reservoir of phosphorus is in the atmosphere. (True/False)
8. Net primary productivity is always more than the gross primary productivity. (True/False)
9. Wave currents bring nutrients in the estuaries which helps in boosting their primary productivity. (True/False)
10. If we want to maintain the ecological balance, we should try to contribute to positive feedback mechanisms. (True/False)
11. Positive feedback mechanisms tend to take the system away from its optimal conditions. (True/False)
12. During ecological succession there is an orderly change in the community structure whereas the physical structure remains constant. (True/False)
13. Landslides, drought, frost or volcanoes can result in development of a bare area for succession to start. (True/False)
14. Orchids are epiphytes found in abundance in tropical rain forests, known for their beautiful flowers. (True/False)
15. Abyssal zone of oceans receive no sunlight and constitute an incomplete ecosystem. (True/False)

## UNIT 4 : BIODIVERSITY AND ITS CONSERVATION

### A. SELECT THE APPROPRIATE ANSWER

1. Which of the following is *not* a biogeographic habitat of India as per classification
   (*a*) Himalayan (*b*) Western ghats
   (*c*) Sunderbans (*d*) Desert.
2. Vinblastin and Vincristine, two anticancer drugs have been obtained from
   (*a*) Periwinkle (*b*) Cinchona
   (*c*) Bacterium (*d*) Jelly fish.
3. Western ghats are very rich in endemic species of
   (*a*) Birds (*b*) Lions
   (*c*) Amphibians (*d*) Turtles.
4. Which of the following hotspots of biodiversity has the maximum number of plant and vertebrate species
   (*a*) Caribbean (*b*) Tropical Andes
   (*c*) Madagascar (*d*) Indo-Burma Eastern Himalayas.

5. Which of the following is an extinct species
   (*a*) Dugong (*b*) Great Indian bustard
   (*c*) Dodo (*d*) Red panda.
6. Which of the following is an example of ex-situ conservation ?
   (*a*) Biosphere reserve (*b*) Gene bank
   (*c*) Sanctuary (*d*) All of these.
7. Kaziranga National Park is famous for
   (*a*) One-horned rhino (*b*) Hangul
   (*c*) Tiger (*d*) Elephant.
8. There are only two sanctuaries in India dealing with preservation of plants. The plants are
   (*a*) Cinchona—Orchid (*b*) Citrus–Pitcher plant
   (*c*) Mango—Citrus (*d*) Mango—Pitcher plant.
9. Cryopreservation of plant seeds and pollen is done at a very low temperature of – 196°C by using
   (*a*) Ice (*b*) Carbon tetrachloride
   (*c*) Liquid nitrogen (*d*) Ammonia.
10. Which one of the following National Parks *do not* have tigers as their main wildlife ?
   (*a*) Gir (*b*) Corbett
   (*c*) Dudwa (*d*) Ranthambore.

## B. FILL IN THE BLANKS

1. When variations occur within a species due to new combinations of genes, this is called ..... diversity.
2. Shannon-Wiener index gives a measure of ..... diversity.
3. Drugs, fuelwood and food derived from biodiversity represent ..... value of biodiversity.
4. Quinine is obtained from the bark of ..... tree.
5. In terms of plant richness, the rank of India in the world is ..... .
6. There are 25 biodiversity hot spots in the world, of which ..... exist in India.
7. Number of species found in a small homogeneous area is known as ..... richness.
8. Species restricted only to a particular area are called ..... .
9. Loss of habitat in instalments leading to small scattered patches is known as ..... .
10. Illegal killing of prohibited endangered animals is called ..... .

11. Red Data Book giving the list of endangered species of plants and animals is published by ..... .
12. Nanda Devi, Manas and Sunderbans are examples of ..... .

## C. TRUE OR FALSE

1. Biodiversity not only includes the variability of all types of living organisms but also the variations within the ecosystems. (True/False)
2. The commercially usable value of biodiversity where the product is marketed and sold is called consumptive use value. (True/False)
3. When ecological surveys are carried out during a tour, it is known as ecotourism. (True/False)
4. Prevention of soil erosion and floods, cycling of nutrients, regulation of water cycle and reduction of global warming by the trees are examples of ecosystem service value. (True/False)
5. The commercial value of a tree timber is much more than its ecological services value. (True/False)
6. Maximum global biodiversity is found in tropical rain forests. (True/False)
7. Amongst the animals, highest number of known living species are that of mammals. (True/False)
8. Terrestrial diversity is much more than marine diversity. (True/False)
9. India has on record 47,000 species of plants and 81,000 species of animals. (True/False)
10. Highest number of known living species of plant kingdom in India belong to fungi. (True/False)
11. Though India is one of the 12 mega diversity countries in the world, yet it is not the centre of origin of any crop species. (True/False)
12. As we move across large landscape gradients the gamma richness increases. (True/False)
13. Human encroachment into forest areas is one of the main reasons for attack by wildlife on humans. (True/False)
14. Endangered animals cannot be prevented from becoming extinct by providing them special protection. (True/False)

## UNIT 5 : ENVIRONMENTAL POLLUTION

### A. FILL IN THE BLANKS

1. The main pollutants emitted by Thermal Power Plants are ..... and ..... .
2. ..... forms the highest proportion in the vehicular exhaust.
3. Sulphur dioxide during coal burning is produced due to oxidation of ..... contained in coal.
4. CO has affinity for haemoglobin ..... times more than oxygen.
5. Air pollutants affects plants by entering through ..... .
6. Sound frequency is expressed in ..... .
7. Noise levels considered as threshold of pain are ..... dB.
8. As per Environmental (Protection) (Second Amendment) Rules, 1999 the permissible noise levels for fire-crackers are ..... dB.
9. Minamata disease occurred due to consumption of fish contaminated with .....
10. Blue baby syndrome is caused by the presence of ..... in drinking water.
11. Power plants utilize only ..... of the energy provided by fossil fuel for their operation.
12. Radioactive strontium affects bones by depositing in the bones instead of ..... .
13. The point where first movement occurs during earthquake is called ..... .
14. Various forms of cyclones are ....., ..... and ..... .

### B. TRUE OR FALSE

1. Benzo-α-pyrene of cigarette smoke is considered to cause cancer. (True/False)
2. $SO_2$ does not affect respiratory passage. (True/False)
3. Washing of coal cannot remove sulphur. (True/False)
4. Sound can propagate without any medium. (True/False)
5. Rocket engine causes 90 dB of noise. (True/False)
6. On Diwali the use of fire-crackers is not permitted between 6.00 pm and 10.00 pm. (True/False)
7. Groundwater is not less prone to contamination due to soil mantle. (True/False)
8. Groundwater contamination is irreversible. (True/False)

9. Waste heat in water does not affect the survival of sensitive species. (True/False)
10. B.O.D. is always higher than C.O.D. (True/False)
11. High temperature increases the dissolved oxygen content in water. (True/False)
12. Solid waste material degraded by micro-organisms are called non-biodegradable. (True/False)
13. Floods leave everything contaminated whom flood water touches. (True/False)
14. Landslides occur when coherent rock of soil masses move downslope. (True/False)

## C. CHOOSE THE CORRECT ANSWER

1. The most important indoor air pollutant is
   (*a*) $SO_2$ (*b*) $CO_2$
   (*c*) $NO_2$ (*d*) Radon gas.
2. Damage to leaf structure by air pollutants causes
   (*a*) Dead areas of leaf (*b*) Chlorophyll reduction
   (*c*) Dropping of leaf (*d*) All of these.
3. Air pollutants mixing up with rain can cause
   (*a*) High acidity (*b*) Low acidity
   (*c*) Neutral conditions (*d*) None of these.
4. Industrial wastes may contain toxic
   (*a*) Chemicals (*b*) Phenols
   (*c*) Acids (*d*) All of these.
5. Dissolved oxygen in water comes from
   (*a*) Photosynthesis of aquatic plants
   (*b*) Atmosphere
   (*c*) None of these (*d*) Both of these.
6. Itai itai disease in Japan was caused by consumption of rice contaminated with
   (*a*) Mercury (*b*) Iron
   (*c*) Cadmium (*d*) Zinc.
7. Thermal pollution can be controlled by
   (*a*) Cooling ponds (*b*) Spray ponds
   (*c*) Cooling towers (*d*) All of these.

**8.** Oil in water affects fish by affecting
(*a*) Gills (*b*) Scales
(*c*) Eyes (*d*) None of these.

**9.** Which of the following have more penetration power ?
(*a*) Alpha particles (*b*) Beta particles
(*c*) Gamma-rays (*d*) None of these.

**10.** Bhopal gas tragedy occurred due to leakage of
(*a*) MIC (*b*) DDT
(*c*) $SO_2$ (*d*) Dioxins.

**11.** Which of the following enhance the frequency of earthquakes ?
(*a*) Big Dams
(*b*) Underground nuclear testing
(*c*) Deep well disposal of liquid wastes
(*d*) All of these.

## UNIT 6 : SOCIAL ISSUES AND THE ENVIRONMENT

### A. FILL IN THE BLANKS

**1.** The concept of sustainable development was given by ..... .

**2.** The 3-R approach of resource use stands for Reduce, Reuse and ..... .

**3.** The number of organisms sustained by any system on a long-term basis is known as its ..... .

**4.** The land area from which water drains under gravity to a common drainage channel is called a ..... .

**5.** Average global temperature is 15°C. In the absence of greenhouse gases the temperature would have been ..... .

**6.** In acid rain, the pH of rain water falls below ..... .

**7.** The atmospheric emissions of $NO_2$ and ..... cause acid rains.

**8.** Ozone layer acts as a natural sunscreen which protects life on this earth against ..... rays.

**9.** Ozone concentration is measured in ..... units.

**10.** Ozone depleting nature of CFC's was first reported by ..... and ..... .

**11.** Due to nuclear fallout, a phenomenon opposite to global warming is expected which is known as ..... .

**12.** Radioactive strontium liberated during nuclear explosion replaces ..... and therefore causes bone deformity.

13. The World Environment Day is celebrated on ..... .
14. The first country in the world to make provisions for environmental protection in its constitution is ..... .
15. ..... Act provides for setting up of National Parks and wildlife sanctuaries.
16. Noise has been included as pollution in the Air (Prevention and Control of Pollution) Act, 1981 in the year ..... .
17. Any appeals filed by the aggrieved industrial unit against the State Pollution Control Board are heard and decided by ..... authority, under the Water and Air Acts.
18. Environmental Protection Act came into force on ..... 1986, the birth anniversary of Smt. Indira Gandhi.

## B. CHOOSE THE CORRECT ANSWER

1. The world famous report on "The Limits to Growth" predicting that the world will meet the doom's day, if growth continues limitlessly, was written by
   (*a*) Myers *et al.* (*b*) Meadows *et al.*
   (*c*) Brundtland (*d*) Wilson *et al.*
2. Which one of the following is *not* associated with reducing the run-off loss of water
   (*a*) Contour cultivation (*b*) Chemical wetting
   (*c*) Surface crop residues (*d*) Fallow soil.
3. Rainwater harvesting has the following advantages
   (*a*) Avoids flooding of roads (*b*) Recharges ground water
   (*c*) Reduces run-off loss (*d*) All the above.
4. Rajendra Singh of "Tarun Bharat Sangh" was awarded Magsaysay Award for his work on
   (*a*) Water conservation (*b*) Social forestry
   (*c*) Clean technology (*d*) Popularisation of solar energy.
5. In Sardar Sarovar Project displacement of about 3 lakh people occurred due to
   (*a*) Submergence of villages (*b*) Underground fires
   (*c*) Severe landslides (*d*) Creation of National Park.
6. Which of the following gases has maximum contribution to enhanced greenhouse effect ?
   (*a*) CFC's (*b*) $CH_4$
   (*c*) $CO_2$ (*d*) $N_2O$.

7. Cattle, sheep and termites are responsible for the release of the following greenhouse gas
   (*a*) Methane (*b*) Carbon dioxide
   (*c*) Nitrous oxide (*d*) All of these.
8. The most important agents for ozone depletion are
   (*a*) Methane (*b*) CFC's
   (*c*) Nuclear fallout (*d*) Nitrous oxide.
9. Maximum depletion of ozone occurs on
   (*a*) Equator (*b*) North pole
   (*c*) South pole (*d*) Tropics.
10. Chernobyl disaster is associated with
   (*a*) Nuclear accident (*b*) Landslide
   (*c*) Earthquake (*d*) Acid rain.
11. Which article in constitution recognizes environmental protection as one of the fundamental duties of every citizen of India
   (*a*) Article 42 (*b*) Article 48A
   (*c*) Article 51A(g) (*d*) Article 52.
12. As per the Forest Act, cultivation of which of the following is a non-forest activity
   (*a*) Tea (*b*) Rubber
   (*c*) Mulberry (*d*) All of these.
13. Which of the following NGO's is associated with 'Chipko Movement' ?
   (*a*) Kalpavriksh (*b*) Srishti
   (*c*) Dasholi Gram Swarajya Mandal
   (*d*) Green Peace.
14. The sensitizing issue of pesticide contamination of cola drinks was brought into limelight by the NGO
   (*a*) Centre for Science and Environment
   (*b*) Bombay Natural History Society
   (*c*) Kerala Sastra Sahitya Parishad
   (*d*) Kalpavriksh.

## C. TRUE OR FALSE

1. Cities have less demands of energy as compared to rural areas. (True/False)
2. *Talaab*, *Bawri*, *Johar* and *Hauz* are examples of ancient rain water harvesting technology. (True/False)

3. As per UN declaration of Human Rights, right to housing is a basic human right. (True/False)
4. The Govt. of India cannot serve notice to people to vacate their lands, as per Land Acquisition Act, 1894. (True/False)
5. Tribals get maximum benefit of big river valley projects, mining projects and National Park Projects, because they actually live in such localities. (True/False)
6. Anthropocentric world-view emphasizes on use and management of earth's resources for the benefit of human beings. (True/False)
7. Due to ozone depletion there will be increased incidence of skin cancer and eye cataract. (True/False)
8. Wastelands can be formed due to anthropogenic activities like deforestation, overgrazing, mining and erroneous agricultural practices. (True/False)
9. Consumption over-population is a characteristic of developing countries. (True/False)
10. The population of India is 3.4 times that of USA but its energy consumption is 1/8th that of USA. (True/False)
11. The Wild Life (Protection) Act, 1972 is adopted all over India including Jammu & Kashmir. (True/False)
12. For any non-forest activity in the forest prior approval of State Govt. is necessary, as per the 1992 amendment in Forest Act. (True/False)
13. The definition of water pollution as per Water (Prevention and Control of Pollution) Act, 1974 includes not only the agents causing harm to any form of life but also those which have a likelihood of doing so. (True/False)
14. Central and State Pollution Control Boards were established in 1996 under the Environmental (Protection) Act. (True/False)
15. One of the major drawbacks of the Forest Conservation Act, 1980 is very poor community participation in it. (True/False)

## UNIT 7 : HUMAN POPULATION AND THE ENVIRONMENT

### A. CHOOSE THE CORRECT ANSWER

1. The present world population has just crossed
   (*a*) 4 billion (*b*) 5 billion
   (*c*) 6 billion (*d*) 8 billion.

2. If a nation has an annual growth rate of 2%, its population will double in
   (*a*) 20 years (*b*) 35 years
   (*c*) 50 years (*d*) 70 years.
3. Expanding population trend is predicted for the coming years when age-pyramid is
   (*a*) Bell-shaped (*b*) Pyramid shaped
   (*c*) Urn-shaped (*d*) None of these.
4. Every ..... person in this world is an Indian.
   (*a*) Fifth (*b*) Sixth
   (*c*) Seventh (*d*) Tenth.
5. Which state in India has the lowest birth rate ?
   (*a*) Kerala (*b*) Bihar
   (*c*) Jammu & Kashmir (*d*) Himachal Pradesh.
6. Chemicals or agents that cause cancer are called
   (*a*) Carcinogenic (*b*) Mutagenic
   (*c*) Teratogenic (*d*) Neurotoxins.
7. In Vienna World Conference on Human Rights, 1993 emphasis was laid for developing countries on
   (*a*) Political rights (*b*) Economic rights
   (*c*) Civil rights (*d*) Cultural rights.
8. Declaration of Human Rights and Environment was drafted by the United Nations at
   (*a*) Stockholm (*b*) Geneva
   (*c*) Rio de Jenerio (*d*) Johannesberg.
9. HIV can pass from infected persons to others by
   (*a*) Contaminated syringe (*b*) Saliva
   (*c*) Sweat (*d*) All of these.
10. United Nations Decade for women has been during
    (*a*) 1965-75 (*b*) 1975-85
    (*c*) 1985-95 (*d*) 1995-2005.
11. CEDAW deals with
    (*a*) Human rights for freedom of speech
    (*b*) Discrimination against women
    (*c*) Value education and awareness
    (*d*) Environmental education.

12. ENVIS generates database on :
    (*a*) Coastal ecology (*b*) Biodiversity
    (*c*) Occupational health (*d*) All of these.

## B. TRUE OR FALSE

1. Need for more man-power in agriculture-based societies has been responsible for an exceptionally high population growth in developing countries. (True/False)
2. Total fertility rate and infant mortality rates are lower in developing countries. (True/False)
3. Life expectancy over the globe has improved over the past century. (True/False)
4. Andhra Pradesh has stabilized its population by paying incentives to poor people whereas in Kerala it has been done by improved social justice. (True/False)
5. Population and poverty in developing countries usually lead to violation of human rights. (True/False)
6. India is a signatory to the World Declaration on Survival, Protection and development of children. (True/False)
7. GIS is a technique of superimposing spatial data using digital information. (True/False)
8. GIS can prove very useful for land-use planning, however, it is not useful for any atmospheric phenomena. (True/False)
9. The Draft Declaration on human rights provides for rights to pollution free environment, rich biodiversity and good quality life, but does not give rights for public participation in environmental decision making. (True/False)
10. Value-based environmental education emphasizes on attaching monetary value to environmental components. (True/False)

## C. FILL IN THE BLANKS

1. When a population increases by a fixed percentage it is called ..... growth.
2. When birth plus immigration in a population are just equal to deaths plus emigration, it is known as ..... .
3. The phenomenon of fall in death rates and birth rates due to improved living conditions leading to low population growth is called ..... .

4. Universal declaration of human rights was given by the UNO in the year ..... .
5. Full form of AIDS is ..... .
6. HIV infected persons show a decline in ..... cells, thereby reducing their immune system.
7. Rights of a child have become International Law in the year ..... to ensure measures for the protection and well being of a child.
8. ..... has been constituted by the Ministry of Environment and Forests for generating database on various environmental aspects.
9. GIS stands for ..... .
10. www stands for ....., which contains a vast quantum of current data on internet.

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# Glossary

**abiotic** : Non living.

**age-structure** : Percentage of men and women in the young, adult and old stage in a population.

**acid rain** : Toxic gases like SOx and NOx dissolve in rain water to form sulphuric acid and nitric acid and come down as acid rain.

**aerobic** : an organism that needs oxygen to carry on.

**anaerobic** : an organism that lives in the absence of oxygen.

**air pollution** : toxic chemicals, excess heat or noise present in the atmosphere in concentrations that are or may be harmful to humans, other animals or plants.

**alley cropping** : Planting trees and crops alternately (also called agro-forestry).

**altitude** : Height above sea-level.

**alpha particle** : Positively charged matter that consists of two protons and two neutrons.

**alpha richness** : Species richness in a small homogeneous area.

**ambient air** : The air surrounding us.

**annual** : Occurring in a year.

**aquifer** : A highly permeable layer of sediment or rock containing water.

**arid** : Dry

**atmosphere** : The mass of air surrounding the earth.

**autotroph** : Organisms that synthesize their own food *e.g.* green plants.

**aerosol** : Minute particles and droplets suspended in the air.

**allergens** : Substances causing allergy.

**anthropogenic** : Human generated; caused by humans.

**bioaccumulation** : Accumulation of non-biodegradable substances in the body.

**biodegradable** : Substances that can be broken down by microbes.

**biodiversity** : Total variability among species of plants, animals and microorganisms.

**biogeochemical cycles** : Cycling of nutrients among living organisms, air, water and soil.

**biogeographical area** : A region with characteristic climatic biological, water and land resources.

**biomagnification** : Increase in concentration of some stable compounds at successive trophic levels in a food chain.

**beta diversity or β-richness** : Variations in species composition across different habitats.

**B.O.D.** : Biological oxygen demand. It is the amount of dissolved oxygen required by microorganisms to break down organic matter present in water.

**biomass** : Organic matter produced by living organisms

**biome** : A broad, regional type of ecosystem with distinct climate, soil conditions, flora and fauna.

**biosphere** : Zone of earth where life is found. It includes air, water and soil.

**biosphere reserve** : World heritage sites identified by IUCN, due to their high biodiversity and unique ecological features, the whole of the ecosystem along with its biodiversity is preserved in these.

**biotic** : Living

**bog** : Water-logged soil usually containing peat.

**boreal forests** : Mixed coniferous and deciduous trees stretching across North America, Europe and Asia.

**cancer** : a disease producing tumors in which cells multiply uncontrollably and invade surrounding tissue.

**carcinogen** : Any agent promoting cancer *e.g.* chemicals, ionizing radiations etc.

**carnivore** : Organism that feeds on other animals.

**carrying capacity** : Maximum population size that a given system can support over a given period of time.

**cell** : The smallest unit of living organisms.

**chlorofluorocarbons (CFCs)** : Chemical compounds with a carbon skeleton and one or more attached chlorine and fluorine atoms; used as refrigerant, solvent, fire retardant and blowing agent.

**chemosynthesis** : Conversion of inorganic substances into organic compounds (by bacteria) in the absence of sunlight.

**chlorophyll** : Green coloured pigment found in green plants.

**climate** : Long term pattern of weather in a particular area.

**climax community** : The ultimate stable community formed during ecological succession, usually a forest.

**closed ecosystem** : Ecosystem having little exchange of nutrients and energy with outside environment.

**closed canopy** : Forests where tree crowns are spread over 20% of the ground.

**coliform bacteria** : Bacteria living in the colon region of human intestine; used as an index of faecal contamination of water.

**commensalism** : A mutualistic relationship in which one organism is benefited while the other is neither benefited nor harmed.

**conifers** : Needle bearing trees producing cones *e.g.* pines.

**consumerism** : Consumption or use of resources.

**community** : Populations of various species living and interacting in a given area.

**compost** : A nutrient rich soil amendment produced by biological degradation of organic material under aerobic conditions

**condensation nuclei** : Tiny particles on which droplets of water vapour can collect.

**conservation tillage farming** : crop farming where soil is least disturbed.

**consumer** : organism who cannot synthesize its own food and get its nutrition by feeding on others.

**consumption overpopulation** : When resource use is at a very high rate resulting in large-scale waste generation and environmental degradation; found in developed nations with less population.

**continental shelf** : Submerged part of a continent.

**contour farming** : Planting across the changing slope rather than in straight lines, to reduce water and soil loss on hills.

**contraceptives** : physical or chemical methods used for family planning.

**coral reefs** : Massive colonies formed by billions of tiny coral animals.

**core** : Inner zone of the earth

**crust** : solid outer zone of the earth

**cyanobacteria** : blue green algae

**consumptive use value** : The direct use values of biodiversity where the product can be harvested and used directly

**confined aquifer** : Aquifer between two relatively impermeable layers of earth.

**DDT** : Dichlorodiphenyl trichloroethane, a pesticide

**deciduous** : Trees that shed their leaves at the end of the growing season.

**decomposers** : Fungi and bacteria that break complex organic matter into simpler molecules and ultimately into inorganic substances.

**delta** : Fan-shaped sediment deposit found at the mouth of a river.

**demography** : Study of human populations.

**demographic transition** : A pattern of falling death rates and birth rates in response to improved living conditions due to industrialization.

**desert** : a biome where evaporation exceeds precipitation.

**desertification** : degradation of once fertile land into a desert like land.

**detritivore** : Organism that consumes organic litter, debris and dung.

**dioxins** : a family of 75 different chlorinated hydrocarbon compounds produced as by-products at high temperature in chemical reactions, usually carcinogenic.

**DNA** : Deoxyribonucleic acid, genetic material.

**doubling time** : Time taken by something (population) to double itself.

**drought** : Condition in which an area does not get enough water due to below normal rainfall.

**drip irrigation** : Use of perforated tubes that give out water dropwise to the soil around each plant.

**detritus** : Dead organic matter.

**deuterium** : Isotope of hydrogen, the nucleus has one proton and one neutron, mass number: 2.

**earthquake** : shaking of ground due to fracturing and displacement of rocks on the earth's crust.

**eco-centric** : a life view advocating moral values and rights both for the human beings and the earth.

**ecology** : Study of interactions of living organisms with their biotic and abiotic environment.

**ecological succession** : The process by which one community is naturally replaced by another one over a period of time.

**ecological services** : Processes or materials provided by ecosystems like pure air, water, nutrients.

**ecosystem** : A biological community and its physical environment exchanging matter and energy.

**ecotourism** : Synthesis of tourism with appreciation of nature and its wild-life.

**endemism** : Restriction of a species to a single region.

**energy** : capacity to do work.

**environment** : The conditions surrounding organisms including all biotic, abiotic components and their interactions.

**ethics** : moral values and principles to guide us.

**environmental impact assessment (EIA)** : A systematic analysis of the effects of a major development project.

**electromagnetic radiations** : Kinetic energy moving as electromagnetic waves *e.g.* TV waves, radio-waves, visible light etc.

**environmental studies** : A systematic study of our environment as well as our role in it.

**epiphyte** : Plants that grow on a substrate like branches of a tree but not on soil; common in tropical forests.

**estuary** : Partially enclosed coastal area at the mouth of a river where fresh and salt water meet.

**eutrophication** : Over-nourishment of water bodies due to excessive nitrates and phosphates received through run-off.

**exponential growth** : Growth at a constant rate of increase per unit of time.

**extinction** : Loss of a species from the earth, a species is said to be extinct if it is not seen in the wild for 50 years.

**family planning** : Planning the timing, spacing and number of offsprings.

**famine** : Acute food shortage.

**fauna** : All the animals present in a given region.

**feedback mechanism** : A mechanism to sense, evaluate and react to environmental changes as a result of information fed back into the system.

**fertilizer** : Substance that adds inorganic or organic nutrients to the soil to improve yield.

**flood plains** : Low lands along river banks, lakes subjected to periodic inundations.

**flora** : All plants present in a given region.

**food chain** : A feeding series in an ecosystem.

**food security** : Ability of human beings to obtain adequate food on regular basis.

**food web** : A complex, interlocking series of food chains.

**fossil fuels** : Fuels produced due to fossilization of plants/animals like petroleum, coal, natural gas.

**fungi** : A group of plants which lack the green pigment chlorophyll, *e.g.* mushrooms, molds etc.

**fungicides** : Chemicals that kill fungi.

**gamma rays** : Very short wavelength ionizing rays with high energy.

**game species** : Wild animals hunted or caught for recreation.

**gasohol** : A fuel that is a mixture of gasoline and alcohol.

**gene** : A unit of heredity, it is either DNA or RNA.

**glacier** : A flowing body of ice.

**GNP** : Gross National Product, an index of a country's economic develoment.

**greenhouse effect** : Trapping of heat by earth's atmosphere due to greenhouse gases like carbon-dioxide, methane, water vapour etc.

**gully erosion** : Removal of layers of soil creating large channels.

**ground water** : Water held in aquifers below the earth's surface.

**habitat** : Place where an organism lives.

**half life** : time required by a substance to decay by half.

**heterotroph** : Organism that can't synthesize its own food and derives its nourishment by feeding on others.

**homeostasis** : An inherent property of living organisms or ecosystems to resist change and remain stable.

**humus** : A dark amorphous substance that is partially degraded and serves as a major source of nutrients to plants.

**hydrocarbon** : Organic compounds of hydrogen and carbon.

**hurricanes** : Cylonic storms with heavy rains and wind with speed exceeding 119 Km/h.

**human rights** : Rights that a human being must enjoy on this earth since he/she is a human being.

**HIV** : Human immunodeficiency virus- a virus causing the dreaded disease AIDS.

**infiltration** : Percolation of water into the soil.

**insolation** : Incoming solar radiations.

**industrial smog** : Air pollution due to a mixture of sulphur dioxide suspended solid particles.

**infant mortality rate** : Number of infants per 1000 born that die before their first birthday.

**invertebrates** : Animals that have no backbone.

**ion** : Atoms with a positive or negative charge.

**isotopes** : Two or more forms of an element that have same number of protons but different mass number due to different number of neutrons.

**latitude** : Distance from the equator.

**leaching** : Process in which various chemicals in upper layers of soil are dissolved and carried to lower layers.

**lethal dose** : The amount of a substance per unit of body weight that kills all the test animals.

**life expectancy** : Average number of years a new born baby is expected to live.

**landslides** : Mass movement of rock or soil down hill.

**lithosphere** : Outer shell of the earth composed of the crust and the rigid outermost part of the mantle.

**magma** : Molten rock below the earth surface.

**malnutrition** : Diet with deficiency of proteins.

**mass number** : Sum of number of neutrons and protons in the nucleus.

**matter** : Anything that has mass *e.g.* nutrients.

**mycorrhiza** : Mutually benificial association between a fungus and roots of higher plants.

**monoculture** : Cultivation of a single crop or tree.

**mutagen** : Chemical or ionizing radiation that cause mutations.

**mutation** : A sudden heritable change.

**marsh** : A wetland without trees.

**mulch** : A protective cover on the ground, may be of dried leaves.

**mutualism** : An association between two organisms so that both of them are benefited, also called symbiosis.

**natural gas** : Underground deposits of gases containing mainly methane and small amounts of propane and butane.

**natural hazards** : Hazards that destroy or damage wild life habitats, damages property and human settlements.

**net primary productivity** : Rate at which plants produce biomass from sunlight.

**neutron** : Elementary particle in the nuclei of all atoms having no electric charge, relative mass = 1 (except hydrogen).

**niche** : The functional role and position of a species in an ecosystem *i.e.* what resources it uses, how does it interact with other species etc.

**nitrogen fixation** : Conversion of atmospheric nitrogen gas into ammonia by nitrogen fixing bacteria/cyanobacteria or by electrification.

**nuclear fission** : nuclei of certain isotopes with large mass number are split apart into lighter nuclei when struck by a neutron releasing large amount of energy.

**nuclear fusion** : Two nuclei of isotopes of lighter elements fuse to form a heavier nucleus releasing a large amount of energy.

**open sea** : Part of the ocean beyond the continental shelf.

**ore** : A metal yielding material.

**organic farming** : Farming involving organic fertilizers and natural pest control, no use of inorganic fertilizers and pesticides.

**oustees** : Native people rooted out of their land/home due to developmental activity.

**omnivores** : Organisms that eat both plants and animals.

**open canopy** : A forest where tree crowns cover less than 20% of the ground.

**PAN** : Peroxyacyl nitrate- a group of chemicals causing photochemical smog.

**particulate matter** : Solid particles or liquid droplets suspended in air.

**parts per million (ppm)** : Number of parts of a chemical found in one million parts of a liquid/gas *e.g.* mg/L.

**pathogen** : Organism that causes disease.

**peat** : Semi-decayed organic matter.

**perennial species** : Plants that grow for more than two years.

**permafrost** : A permanently frozen layer of soil in Arctic Tundra.

**pH** : Numeric value that indicates the relative acidity or alkalinity; varies from 0-14 with neutral point at 7; less than 7 is acidic and more than 7 is alkaline.

**photochemical smog** : Mixture of air pollutants (generally coming along with vehicular exhaust) consisting of hydrocarbons and oxides of nitrogen and formed in the presence of sunlight.

**photosynthesis** : Synthesis of food by green plants in the presence of sunlight using carbon dioxide and water.

**photovoltaic cell (PV cell)** : Solar cell that converts solar energy into electricity.

**phytoplanktons** : Small plants like algae, bacteria found floating on the surface of water.

**pioneer species** : The species which colonize the bare soil first of all.

**poaching** : Illegal commercial hunting or fishing.

**productive use value** : The commercially usable values (of biodiversity) where the product is marketed and sold.

**point source** : A single identifiable source that discharges pollutants into the environment.

**polychlorinated biphenyls (PCBs)** : Group of 209 different toxic, oily, synthetic chlorinated hydrocarbons, biomagnified usually in food chain.

**population** : Group of individual organism of a species living within a particular area.

**population explosion** : Exponential growth of population to a size that exceeds the carrying capacity.

**predator** : Organism that feeds directly on other organism to survive.

**primary pollutants** : Chemicals released directly into the air.

**radioactive substance** : The substance (isotope) that spontaneously emits one or more types of radiations like alpha particles, beta particles or gamma rays.

**runoff** : The excess of precipitation that does not evaporate or infiltrate.

**rangelands** : Grasslands.

**remediation** : Cleaning up chemical contaminants from polluted area.

**rehabilitation** : Re-establishing the oustees OR restructuring the ecological system that has been degraded.

**residence time** : The length of time for which a chemical or molecule stays in the environment.

**salinity** : Amount of soluble salts in water or soil.

**sanitary landfill** : Waste disposal site on land in which waste is spread in thin layers, compacted and covered with fresh layer of clay.

**secondary pollutant** : Harmful pollutants formed by the reaction of two or more primary pollutants in the air.

**sludge** : Settled solids removed from wastewaters.

**smelting** : Process of separating the desired metal from an ore.

**species** : All the organisms genetically similar, breeding freely but reproductively isolated from other species.

**stress** : Such factors that cause a strain on an organism.

**sustainable development** : Increase in standard of life that can be maintained over a long-term without degrading the environment or compromising the ability of future generations to meet their own needs.

**synergism** : When the effect of two factors together is more than the sum of exposure to each factor individually.

**tailings** : Mining wastes.

**tectonic plates** : Huge blocks of earth's crust that slide along slowly.

**teratogens** : Chemicals or other agents that cause abnormalities during embryonic growth and development.

**terracing** : Shaping the land to create level shelves on hill slopes.

**thermodynamics** : A branch that deals with transfer and conversions of energy.

**toxins** : Poisonous chemicals harmful even in small concentrations.

**transpiration** : Loss of water from plant surfaces.

**troposphere** : The layer of air nearest to earth's surface; both temperature and pressure usually decrease in this layer with increasing altitude.

**tundra** : Treeless arctic or alpine biome.

**stratosphere** : Second layer in the atmosphere above troposphere.

**urbanization** : Increasing concentration of population in cities.

**unconfined aquifer** : Groundwater above a layer of earth material with low permeability.

**upwelling** : Movement of nutrient rich bottom water to ocean's surface.

**vertebrates** : Animals with backbones.

**volcano** : Emission of magma from a fissure/vent in earth's surface releasing liquid lava and gases.

**water logging** : Saturation of soil with irrigation water or excessive precipitation so that water table rises close to surface.

**water shed** : The land area from which water drains under gravity to a common drainage channel.

**weather** : Description of physical conditions of the atmosphere.

**pollution** : Environmental condition in which certain substances (including the normal constituents in excess) are present in concentrations that can cause undesirable effects on man and his environment.

**wetlands** : Ecosystems with standing water and having rooted vegetation.

**wild life** : Undomesticated life forms.

**X-ray** : Very short wavelength rays, useful in medical diagnosis. Can cause mutations.

**zero population growth (ZPG)** : When births and immigration in a population just equals deaths and emigration.

**zooplankton** : Small floating animals on surface of water feeding on phytoplanktons.

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